EPA WORK ASSIGNMENT NUMBER: 04-1L43

EPA CONTRACT NUMBER: 68-01-7250

EBASCO SERVICES INCORPORATED

DRAFT FEASIBILITY STUDY

ESTUARY AND LOWER HARBOR/BAY

NEW BEDFORD HARBOR
MASSACHUSETTS

VOLUME I

APRIL 1990

Prepared by:

Hans-Peter Krahn
Feasibility Study Lead
E.C. Jordan Co.

Submitted by:

Douglas C. Allen, P.E.
Site Manager
E.C. Jordan Co.

Approved by:

Alan S. Fowler
Project Lead
Ebasco Services, Inc.

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS

Section	Title	Page No.
	VOLUME I	
	EXECUTIVE SUMMARY	ES-1
1.0	INTRODUCTION	1-1
1.1	BACKGROUND	1-1
1.2	PURPOSE AND APPROACH	1-6
1.2.1	Operable Units for the New Bedford Harbor Feasibility Study	1-6
1.2.2	The Hot Spot Operable Unit	1-9
1.2.3	The Estuary and Lower Harbor/Bay Operable Unit	1-9
1.3	REPORT ORGANIZATION	1-10
2.0	SITE DESCRIPTION	2-1
2.1	BACKGROUND	2-1
2.1.1	Site Topography and Bathymetry	2-1
2.1.1.1	Acushnet River Estuary	2-1
2.1.1.2	Lower Harbor	2-2
2.1.1.3	Upper Buzzards Bay	2-2
2.1.2	Source of Contamination	2-3
2.2	EXTENT OF CONTAMINATION	2-4
2.2.1	Methodology for Data Interpretation	2-5
2.2.2	Contamination in the Estuary	2-6
2.2.2.1	Polychlorinated Biphenyls	2-7
2.2.2.2	Metals	2-11
2.2.3	Contamination in the Lower Harbor/Bay	2-15
2.2.3.1	Polychlorinated Biphenyls	2-15
2.2.3.2	Metals	2-17
2.2.4	Determination of Sediment Areas and Volumes for Potential Remediation	2-17
2.2.4.1	Upper Estuary	2-19
2.2.4.2	Lower Harbor/Bay	2-22

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
2.3	CONTAMINANT TRANSPORT AND FATE.	2-22
2.3.1	Transport of Polychlorinated Biphenyls.	2-22
2.3.1.1	The TEMPEST/FLESCOT Model .	2-23
2.3.1.2	TEMPEST/FLESCOT Formulation for New Bedford Harbor. . .	2-23
2.3.1.3	Calibration of the TEMPEST/ FLESCOT Model	2-25
2.3.1.4	Transport Processes Simulated by the TEMPEST/FLESCOT Model	2-26
2.3.1.5	Other Transport Studies . .	2-31
2.3.1.6	Long-term Transport	2-33
2.3.1.7	Summary of the TEMPEST/ FLESCOT Model Results . . .	2-36
2.3.2	Fate of Polychlorinated Biphenyls. .	2-37
2.3.2.1	The WASTOX Model.	2-38
2.3.2.2	WASTOX Formulation for New Bedford Harbor.	2-38
2.3.2.3	Calibration of the WASTOX Model	2-40
2.3.2.4	Long-term Fate.	2-49
2.3.2.5	Other Fate Processes. . . .	2-53
3.0	SUMMARY OF BASELINE PUBLIC HEALTH AND ECOLOGICAL RISK ASSESSMENT	3-1
3.1	SUMMARY OF BASELINE PUBLIC HEALTH RISK ASSESSMENT.	3-1
3.1.1	Methodology.	3-3
3.1.2	Results of the Public Health Risk Assessment for the Lower Harbor/Bay.	3-7
3.1.2.1	Sediment.	3-7
3.1.2.2	Biota	3-8

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
3.2	ECOLOGICAL RISK ASSESSMENT	3-9
3.2.1	Methodology	3-9
3.2.2	Results of Environmental Baseline Assessment	3-10
3.3	OTHER APPROACHES TO EVALUATING ECOLOGICAL RISK	3-14
3.3.1	Equilibrium Partitioning	3-14
3.3.2	Apparent Effects Threshold	3-15
3.3.3	Screening Level Concentrations	3-15
3.3.4	Sediment Quality Triad	3-16
3.3.5	Summary	3-17
4.0	IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES, APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS, AND GENERAL RESPONSE ACTIONS	4-1
4.1	INTRODUCTION	4-1
4.2	SITE-SPECIFIC ARARS	4-2
4.2.1	Definition of ARARs	4-4
4.2.2	Development of ARARs	4-5
4.2.2.1	Chemical-specific ARARs	4-5
4.2.2.2	Location-specific ARARs	4-7
4.2.2.3	Action-specific ARARs	4-11
4.3	DEVELOPMENT OF TARGET CLEAN-UP LEVELS	4-12
4.3.1	Public Health Target Clean-up Levels	4-17
4.3.1.1	Public Health Target Clean-up Levels for Sediment	4-17
4.3.1.2	Public Health Target Clean-up Levels for Biota	4-18
4.3.2	Ecological Target Clean-up Levels	4-20
4.3.2.1	Ecological Target Clean-up Levels for Surface Water	4-20
4.3.2.2	Ecological Target Clean-up Levels for Sediment	4-22

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
4.4	DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES	4-23
4.5	REMEDIAL ACTION OBJECTIVES	4-28
4.6	GENERAL RESPONSE ACTIONS	4-28
	VOLUME II	
5.0	IDENTIFICATION, SCREENING, AND EVALUATION OF TECHNOLOGIES	5-1
5.1	INTRODUCTION	5-1
5.2	IDENTIFICATION AND SCREENING OF TECHNOLOGIES	5-1
5.3	DETAILED EVALUATION OF TECHNOLOGIES	5-8
5.3.1	Dredging/Excavation	5-8
5.3.1.1	U.S. Army Corps of Engineers	5-11
5.3.1.2	Summary	5-19
5.3.2	Treatment	5-20
5.3.2.1	Sediment Treatment	5-20
5.3.2.2	Water Treatment	5-40
5.3.2.3	Summary	5-42
5.3.3	Disposal	5-43
5.3.3.1	U.S. Army Corps of Engineers Laboratory Studies	5-43
5.3.3.2	Conceptual Disposal Alternatives	5-44
5.3.3.3	U.S. Army Corps of Engineers Pilot Study of Disposal Alternatives	5-52
5.3.3.4	Summary	5-53
5.3.4	Containment and In Situ Treatment	5-53
5.4	REMEDIAL TECHNOLOGIES APPLICABLE TO THE ESTUARY AND LOWER HARBOR/BAY	5-56

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
6.0	DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES	6-1
6.1	DEVELOPMENT OF REMEDIAL ALTERNATIVES	6-1
6.1.1	Development of Alternatives for the Acushnet River Estuary	6-2
6.1.2	Development of Remedial Alternatives for the Lower Harbor/Bay	6-2
6.2	CRITERIA FOR SCREENING REMEDIAL ALTERNATIVES	6-9
6.2.1	Effectiveness	6-9
6.2.2	Implementability	6-10
6.2.3	Cost	6-10
6.3	SCREENING OF REMEDIAL ALTERNATIVES FOR THE ESTUARY AND LOWER HARBOR/BAY	6-10
6.3.1	No-Action: Alternatives EST-NA-1 and LHB-NA-1	6-10
6.3.2	Capping: Alternatives EST-CONT-1 and LHB-CONT-1	6-13
6.3.3	Hydraulic Control Capping: Alternative EST-CONT-2	6-17
6.3.4	Dredge/On-site Disposal/Water Treatment: EST-DISP-1 and LHB-DISP-1	6-19
6.3.5	Dredge/Temporary Storage/Disposal CAD: Alternative EST-DISP-2	6-22
6.3.6	Remove Sediments/Dewater/Treat Water/ Solidify Dewatered Sediments/On-site Disposal: Alternatives EST-TREAT-1 and LHB-TREAT-1	6-26
6.3.7	Dredge/Dewater/Treat Water/Solvent Extraction of Dewatered Sediment/On-site Disposal: Alternatives EST-TREAT-2 and LHB-TREAT-2	6-28
6.3.8	Remove Sediments/Dewater/Treat Water/ Thermally Treat Dewatered Sediments/Treat Process Residuals/On-site Disposal: Alternatives EST-TREAT-3 and LHB-TREAT-3	6-31

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
6.4	SCREENING SUMMARY	6-34
6.4.1	Estuary	6-34
6.4.2	Lower Harbor/Bay	6-35
7.0	DETAILED ANALYSIS OF ALTERNATIVES	7-1
7.1	INTRODUCTION	7-1
7.2	ALTERNATIVES EST-1 AND LHB-1: NO-ACTION	7-2
7.2.1	General Description	7-2
7.2.2	Short-term Effectiveness	7-5
7.2.3	Long-term Effectiveness and Permanence	7-6
7.2.4	Reduction in Mobility, Toxicity, and Volume	7-10
7.2.5	Implementation	7-11
7.2.5.1	Technical Feasibility	7-11
7.2.5.2	Administrative Feasibility	7-11
7.2.5.3	Availability of Services and Materials	7-11
7.2.6	Cost	7-11
7.2.7	Compliance with ARARs	7-14
7.2.8	No-Action Overall Protection of Public Health and the Environment	7-17
7.3	ALTERNATIVES EST-2 AND LHB-2: CAPPING	7-17
7.3.1	General Description	7-17
7.3.1.1	Estuary Capping	7-19
7.3.1.2	Lower Harbor/Bay Capping	7-23
7.3.2	Short-term Effectiveness	7-26
7.3.3	Long-term Effectiveness and Permanence	7-26
7.3.4	Reduction in Mobility, Toxicity, and Volume	7-28
7.3.5	Implementation	7-29
7.3.5.1	Technical Feasibility	7-29
7.3.5.2	Administrative Feasibility	7-30

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
7.3.5.3	Availability of Services and Materials	7-30
7.3.6	Cost	7-30
7.3.7	Compliance with ARARs	7-35
7.3.8	Overall Protection of Public Health and the Environment	7-39
7.4	ALTERNATIVES EST-3 AND LHB-3: REMOVAL AND ON-SITE DISPOSAL	7-39
7.4.1	General Description	7-39
7.4.2	Short-term Effectiveness	7-54
7.4.3	Long-term Effectiveness and Permanence	7-55
7.4.4	Reduction in Mobility, Toxicity, and Volume	7-59
7.4.5	Implementation	7-61
7.4.5.1	Technical Feasibility	7-61
7.4.5.2	Administrative Feasibility	7-64
7.4.5.3	Availability of Services and Materials	7-65
7.4.6	Cost	7-65
7.4.7	Compliance with ARARs	7-74
7.4.8	Overall Protection of Public Health and the Environment	7-81
7.5	ALTERNATIVES EST-4 AND LHB-4: REMOVAL, SOLIDIFICATION, AND ON-SITE DISPOSAL	7-81
7.5.1	General Description	7-81
7.5.2	Short-term Effectiveness	7-87
7.5.3	Long-term Effectiveness and Permanence	7-87
7.5.4	Reduction in Mobility, Toxicity, and Volume	7-87
7.5.5	Implementation	7-88
7.5.5.1	Technical Feasibility	7-88
7.5.5.2	Administrative Feasibility	7-89
7.5.5.3	Availability of Services and Materials	7-89
7.5.6	Cost	7-90
7.5.7	Compliance with ARARs	7-95
7.5.8	Overall Protection of Public Health and the Environment	7-99

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
7.6	ALTERNATIVES EST-5 AND LHB-5: REMOVAL, SOLVENT EXTRACTION, AND ON-SITE DISPOSAL. .	7-99
7.6.1	General Description	7-99
7.6.2	Short-term Effectiveness	7-104
7.6.3	Long-term Effectiveness and Permanence	7-106
7.6.4	Reduction in Mobility, Toxicity, and Volume	7-106
7.6.5	Implementation	7-107
7.6.5.1	Technical Feasibility . . .	7-107
7.6.5.2	Administrative Feasibility.	7-108
7.6.5.3	Availability of Services and Materials	7-108
7.6.6	Cost	7-108
7.6.7	Compliance with ARARs.	7-114
7.6.8	Overall Protection of Public Health and the Environment	7-117
7.7	ALTERNATIVES EST-6 AND LHB-6: REMOVAL, INCINERATION, AND ON-SITE DISPOSAL.	7-117
7.7.1	General Description	7-117
7.7.2	Short-term Effectiveness	7-121
7.7.3	Long-term Effectiveness and Permanence	7-124
7.7.4	Reduction in Mobility, Toxicity, and Volume	7-124
7.7.5	Implementation	7-124
7.7.5.1	Technical Feasibility . . .	7-124
7.7.5.2	Administrative Feasibility.	7-127
7.7.5.3	Availability of Services and Materials	7-127
7.7.6	Cost	7-127
7.7.7	Compliance with ARARs.	7-135
7.7.8	Overall Protection of Public Health and the Environment	7-135

TABLE OF CONTENTS
(Continued)

Section	Title	Page No.
8.0	COMPARISON OF REMEDIAL ALTERNATIVES.	8-1
8.1	Short-term Effectiveness.	8-1
8.2	Long-term Effectiveness and Permanence. . .	8-1
8.3	Reduction in Mobility, Toxicity, and Volume	8-2
8.4	Implementability.	8-3
8.5	Cost.	8-3
8.6	Compliance with ARARS	8-4
8.7	Overall Protection of Public Health and the Environment	8-4

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

REFERENCES

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

LIST OF TABLES

Table	Title	Page No.
ES-1	COMPARATIVE ANALYSIS SUMMARY TABLE	ES-8
2-1	AREAS AND VOLUMES FOR ASSOCIATED TARGET CLEAN-UP LEVELS IN SEDIMENT	2-21
2-2	NET FLUX OF SUSPENDED SEDIMENT AND TOTAL PCBS IN KILOGRAMS PER TIDAL CYCLE	2-27
2-3	COMPUTED NET FLUX OF SUSPENDED SEDIMENT AND TOTAL PCBS IN KG/TIDAL CYCLE	2-29
2-4	COMPUTED MASS BALANCE FOR NO ACTION	2-29
2-5	COMPUTED NET FLUX OF SUSPENDED SEDIMENT AND TOTAL PCBS IN KG/TIDAL CYCLE FOR YEAR ZERO AND YEAR 10	2-35
2-6	COMPUTED MASS BALANCE FOR 10-YEAR NO-ACTION SIMULATION	2-35
3-1	PCB AND METALS SEDIMENT CONCENTRATIONS (ppm) USED TO ASSESS DIRECT CONTACT AND INGESTION EXPOSURES	3-5
4-1	POTENTIAL CHEMICAL-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE	4-6
4-2	POTENTIAL LOCATION-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE	4-8
4-3	POTENTIAL ACTION-SPECIFIC ARARS	4-13
4-4	PUBLIC HEALTH TARGET CLEAN-UP LEVELS FOR SEDIMENT	4-19
4-5	PUBLIC HEALTH TARGET CLEAN-UP LEVELS FOR BIOTA (LOWER HARBOR/BAY)	4-21
5-1	TECHNOLOGY TYPES AND PROCESS OPTIONS IDENTIFIED FOR NEW BEDFORD HARBOR	5-3

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

LIST OF TABLES
(Continued)

Table	Title	Page No.
5-2	CONTAMINANT RELEASE ESTIMATES DURING DREDGING IN UPPER ESTUARY.	5-14
5-3	CONTAMINANT RELEASE ESTIMATES DURING DREDGING BELOW COGGESHALL STREET BRIDGE. . . .	5-16
5-4	BENCH- AND PILOT-SCALE TESTS OF SEDIMENT TREATMENT TECHNOLOGIES	5-23
5-5	RESULTS OF BENCH- AND PILOT-SCALE TESTS OF TREATMENT TECHNOLOGIES CONDUCTED FOR NEW BEDFORD HARBOR	5-24
5-6	POTENTIAL LOCATIONS AND CAPACITIES OF CONFINED DISPOSAL FACILITIES IN NEW BEDFORD HARBOR	5-47
7-1	COST ESTIMATE: ALTERNATIVE EST-1, NO-ACTION .	7-12
7-2	COST ESTIMATE: ALTERNATIVE LHB-1, NO-ACTION .	7-13
7-3	COST ESTIMATE: ALTERNATIVE EST-2, CAPPING . .	7-31
7-4	COST ESTIMATE: ALTERNATIVE LHB-2, CAPPING . .	7-32
7-5	SENSITIVITY ANALYSIS: ALTERNATIVE EST-2, CAPPING.	7-36
7-6	SENSITIVITY ANALYSIS: ALTERNATIVE LHB-2, CAPPING.	7-37
7-7	COST ESTIMATE: ALTERNATIVES EST-3 AND 3d, DREDGE/DISPOSE	7-66
7-8	COST ESTIMATE: ALTERNATIVE LHB-3, DREDGE/ DISPOSE.	7-67
7-9	SENSITIVITY ANALYSIS: ALTERNATIVE EST-3, DREDGE/DISPOSE	7-75

LIST OF TABLES
(Continued)

Table	Title	Page No.
7-10	SENSITIVITY ANALYSIS: ALTERNATIVE EST-3d, DREDGE/DEWATER/DISPOSE	7-76
7-11	SENSITIVITY ANALYSIS: ALTERNATIVE LHB-3, DREDGE/DISPOSE	7-77
7-12	SENSITIVITY ANALYSIS: ALTERNATIVE LHB-3d DREDGE/DEWATER/DISPOSE	7-78
7-13	COST ESTIMATE: ALTERNATIVE EST-4, DREDGE/ SOLIDIFY/DISPOSE	7-91
7-14	COST ESTIMATE: ALTERNATIVE LHB-4, DREDGE/ SOLIDIFY/DISPOSE	7-92
7-15	SENSITIVITY ANALYSIS: ALTERNATIVE EST-4, DREDGE/SOLIDIFY/DISPOSE	7-96
7-16	SENSITIVITY ANALYSIS: ALTERNATIVE LHB-4, DREDGE/SOLIDIFY/DISPOSE	7-97
7-17	COST ESTIMATE: ALTERNATIVE EST-5, DREDGE/ SOLVENT EXTRACT/DISPOSE	7-109
7-18	COST ESTIMATE: ALTERNATIVE LHB-5, DREDGE/ SOLVENT EXTRACT/DISPOSE	7-110
7-19	SENSITIVITY ANALYSIS: ALTERNATIVE EST-5, DREDGE/SOLVENT EXTRACT/DISPOSE	7-115
7-20	SENSITIVITY ANALYSIS: ALTERNATIVE LHB-5, DREDGE/SOLVENT EXTRACT/DISPOSE	7-116
7-21	COST ESTIMATE: ALTERNATIVE EST-6, DREDGE/ INCINERATE/DISPOSE	7-128
7-22	COST ESTIMATE: ALTERNATIVE LHB-6, DREDGE/ INCINERATE/DISPOSE	7-129
7-23	SENSITIVITY ANALYSIS: ALTERNATIVE EST-6, DREDGE/INCINERATE/DISPOSE	7-133

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

LIST OF TABLES
(Continued)

Table	Title	Page No.
7-24	SENSITIVITY ANALYSIS: ALTERNATIVE LHB-6, DREDGE/INCINERATE/DISPOSE	7-134
8-1	COMPARATIVE ANALYSIS SUMMARY TABLE.	8-8

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

LIST OF FIGURES

Figure	Title	Page No.
ES-1	TECHNOLOGY TYPES AND PROCESS OPTIONS RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT	ES-4
ES-2	COMPARATIVE COST ANALYSIS FOR EST	ES-6
ES-3	COMPARATIVE COST ANALYSIS FOR LHB	ES-7
1-1	HARBOR LOCATION MAP	1-2
1-2	HARBOR FISHING CLOSURE AREAS	1-3
1-3	SITE LOCATION MAP	1-7
1-4	UPPER ACUSHNET RIVER	1-8
2-1	INTERPRETATION OF TOTAL PCB CONCENTRATIONS, DEPTH: ZERO TO 12 INCHES	2-8
2-2	INTERPRETATION OF TOTAL PCB CONCENTRATIONS, DEPTH: 12 TO 24 INCHES	2-9
2-3	INTERPRETATION OF TOTAL PCB CONCENTRATIONS, DEPTH: 24 TO 36 INCHES	2-10
2-4	INTERPRETATION OF TOTAL METALS CONCENTRATIONS (CADMIUM, COPPER, CHROMIUM, LEAD), DEPTH: ZERO TO 12 INCHES	2-12
2-5	INTERPRETATION OF TOTAL METALS CONCENTRATIONS (CADMIUM, COPPER, CHROMIUM, LEAD), DEPTH: 12 TO 24 INCHES	2-13
2-6	INTERPRETATION OF TOTAL METALS CONCENTRATIONS (CADMIUM, COPPER, CHROMIUM, LEAD), DEPTH: 24 TO 36 INCHES	2-14
2-7	INTERPRETATION OF TOTAL PCB CONCENTRATIONS, DEPTH: ZERO TO 6 INCHES	2-16
2-8	INTERPRETATION OF TOTAL METALS CONCENTRATIONS, (CADMIUM, CHROMIUM, COPPER, LEAD), DEPTH: ZERO TO 6 INCHES	2-18
2-9	UPPER ESTUARY GRID SYSTEM	2-20
2-10	COMPUTATIONAL GRID FOR TEMPEST/FLESCOT MODEL	2-24

LIST OF FIGURES
(Continued)

Figure	Title	Page No.
2-11	BOX AVERAGE ZONES AND FLUX CALCULATION PLANES	2-28
2-12	STUDY AREAS FOR WASTOX MODEL	2-39
2-13	WASTOX MODEL LOBSTER FOOD CHAIN	2-41
2-14	WASTOX MODEL FLOUNDER FOOD CHAIN	2-42
2-15	OBSERVED AND COMPUTED PCB HOMOLOG 3 CONCENTRATIONS IN NEW BEDFORD HARBOR ANIMALS	2-44
2-16	OBSERVED AND COMPUTED PCB HOMOLOG 4 CONCENTRATIONS IN NEW BEDFORD HARBOR ANIMALS	2-45
2-17	OBSERVED AND COMPUTED PCB HOMOLOG 5 CONCENTRATIONS IN NEW BEDFORD HARBOR ANIMALS	2-46
2-18	OBSERVED AND COMPUTED PCB HOMOLOG 6 CONCENTRATIONS IN NEW BEDFORD HARBOR ANIMALS	2-47
2-19	OBSERVED AND COMPUTED TOTAL PCB CONCENTRATIONS IN NEW BEDFORD HARBOR ANIMALS	2-48
2-20	NO-ACTION ALTERNATIVE: AREA 1	2-50
2-21	NO-ACTION ALTERNATIVE: AREA 2	2-51
2-22	NO-ACTION ALTERNATIVE: AREA 3	2-52
3-1	AREAS USED TO ASSESS HUMAN EXPOSURE TO WATER AND SEDIMENT	3-2
3-2	LOCATIONS EVALUATED FOR DIRECT CONTACT AND INGESTION EXPOSURE TO CONTAMINANTS IN SEDIMENTS	3-4
3-3	HARBOR ZONATION AS IN PHYSICAL/CHEMICAL TRANSPORT MODEL	3-11
4-1	OVERVIEW OF THE FS PROCESS	4-3
4-2	ESTUARY AREA TO BE REMEDIATED	4-26
4-3	LOWER HARBOR/BAY AREAS TO BE REMEDIATED	4-27

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

LIST OF FIGURES
(Continued)

Figure	Title	Page No.
5-1	GENERAL RESPONSE ACTIONS AND TECHNOLOGY TYPES IDENTIFIED FOR NEW BEDFORD HARBOR	5-2
5-2	REMEDIAL TECHNOLOGIES RETAINED FOR DETAILED EVALUATION.	5-7
5-3	DISPOSAL FACILITY SITING MAP.	5-46
5-4	RCRA-TYPE LINER SYSTEM FOR CONTAINED DISPOSAL FACILITIES.	5-49
5-5	TYPICAL IN-WATER DIKE SECTIONS.	5-50
5-6	TYPICAL LAND DIKE SECTIONS.	5-51
5-7	TECHNOLOGY TYPES AND PROCESS OPTIONS RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT	5-57
6-1	DEVELOPMENT OF NONREMOVAL ALTERNATIVES.	6-3
6-2	DEVELOPMENT OF REMOVAL ALTERNATIVES.	6-4
6-3	SHIPCHANNEL AREA.	6-6
6-4	SHORELINE AREA.	6-7
6-5	OUTLYING AREAS.	6-8
6-6	EST-NA-1 AND LHB-NA-1: NO-ACTION.	6-12
6-7	EST-CONT-1 AND LHB-CONT-1: CAPPING.	6-15
6-8	EST-CONT-2: HYDRAULIC CONTROL/CAPPING	6-18
6-9	EST-DISP-1 AND LHB-DISP-1: ON-SITE DISPOSAL . .	6-21
6-10	EST-DISP-2: DREDGE/DISPOSE CAD	6-24
6-11	EST-TREAT-1 AND LHB-TREAT-1: DREDGE/SOLIDIFY/ DISPOSE	6-27
6-12	EST-TREAT-2 AND LHB-TREAT-2: DREDGE/SOLVENT EXTRACT/TREAT RESIDUALS/DISPOSE.	6-30

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

LIST OF FIGURES
(Continued)

Figure	Title	Page No.
6-13	EST-TREAT-3 AND LHB-TREAT-3: DREDGE/INCINERATE/ TREAT RESIDUALS/DISPOSE	6-32
7-1	EST-1 AND LHB-1: NO-ACTION	7-3
7-2	WATER COLUMN PCB CONCENTRATIONS FOR THE NO-ACTION ALTERNATIVE	7-7
7-3	COST BREAKDOWN EST-1	7-15
7-4	COST BREAKDOWN LHB-1.	7-16
7-5	EST-2 AND LHB-2: NO-ACTION	7-18
7-6	PLACEMENT OF GEOTEXTILE FOR CAPPING	7-21
7-7	PLACEMENT OF CAPPING MATERIAL	7-22
7-8	AREAS SUITABLE FOR CAPPING IN LOWER HARBOR/BAY.	7-25
7-9	CAPPING IMPACTS TO ESTUARY.	7-27
7-10	COST ESTIMATE EST-2:.	7-33
7-11	COST BREAKDOWN LHB-2:	7-34
7-12	EST-3 AND LHB-3: DREDGE/ON-SITE DISPOSAL . . .	7-40
7-13	ALTERNATIVES EST-3 AND LHB-3: FACILITY SITING MAP.	7-41
7-14	ALTERNATIVES EST-3 AND LHB-3: MASS BALANCE . .	7-43
7-15	TYPICAL CONFINED DISPOSAL FACILITY.	7-45
7-16	EST-3D AND LHB-3D: DREDGE/ON-SITE DISPOSAL . .	7-47
7-17	ALTERNATIVES EST-3D AND LHB-3D: FACILITY SITING MAP.	7-48
7-18	ALTERNATIVES EST-3D AND LHB-3D: MASS BALANCE .	7-49

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

LIST OF FIGURES
(Continued)

Figure	Title	Page No.
7-19	TREATMENT SITE LOCATIONS.	7-52
7-20	WATER COLUMN PCB CONCENTRATIONS IN THE ESTUARY	7-56
7-21	WATER COLUMN PCB CONCENTRATIONS IN THE LOWER HARBOR.	7-58
7-22	WATER COLUMN PCB CONCENTRATIONS IN THE UPPER ESTUARY AND LOWER HARBOR.	7-60
7-23	COST BREAKDOWN EST-3	7-68
7-24	COST BREAKDOWN EST-3D	7-69
7-25	COST BREAKDOWN LHB-3.	7-70
7-26	COST BREAKDOWN LHB-3D	7-71
7-27	EST-4 AND LHB-4: DREDGE/SOLIDIFY/DISPOSE . . .	7-83
7-28	ALTERNATIVES EST-4 AND LHB-4: MASS BALANCE . .	7-84
7-29	ALTERENATIVES EST-4 AND LHB-4: FACILITY SITING MAP.	7-85
7-30	COST BREAKDOWN EST-4.	7-93
7-31	COST BREAKDOWN LHB-4.	7-94
7-32	EST-5 AND LHB-5: DREDGE/SOLVENT EXTRACT/TREAT RESIDUALS/DISPOSE	7-100
7-33	B.E.S.T. SOIL CLEAN-UP UNIT SCHEMATIC	7-102
7-34	ALTERNATIVES EST-5 AND LHB-5: FACILITY SITING MAP.	7-103
7-35	ALTERNATIVES EST-5 AND LHB-5: SOLVENT EXTRACTION MASS BALANCE	7-105
7-36	COST ESTIMATE EST-5:	7-112

LIST OF FIGURES
(Continued)

Figure	Title	Page No.
7-37	COST BREAKDOWN LHB-5:	7-113
7-38	EST-6 AND LHB-6: DREDGE/INCINERATE/TREAT RESIDUALS/DISPOSE	7-119
7-39	ALTERNATIVES EST-6 AND LHB-6: INCINERATION	7-122
7-40	ALTERNATIVES EST-6 AND LHB-6: MASS BALANCE	7-123
7-41	COST BREAKDOWN EST-6.	7-130
7-42	COST BREAKDOWN LHB-6.	7-131
8-1	COMPARATIVE COST ANALYSIS FOR EST	8-5
8-2	COMPARATIVE COST ANALYSIS FOR LHB	8-6

EXECUTIVE SUMMARY

A range of remedial action alternatives was developed for the New Bedford Harbor Superfund site to address potential threats to public health and the environment due to polychlorinated biphenyls (PCB)-contaminated sediments present in the Acushnet River estuary and New Bedford Harbor.

New Bedford, Massachusetts, home port of one of the largest commercial fishing fleets in the U.S., is located approximately 55 miles south of Boston at the head of Buzzards Bay. In 1979, New Bedford Harbor and upper Buzzards Bay were closed to fishing due to PCB contamination and PCB accumulation in marine biota. The New Bedford Harbor site was added to the U.S. Environmental Protection Agency (EPA) Superfund National Priorities List in 1982.

The PCB contamination was introduced into the estuary and harbor primarily as a result of the discharge of process wastewaters from electronics component manufacturing companies in New Bedford. The most heavily contaminated sediments are located in the top 12 inches, where PCB concentrations exceed 4,000 parts per million (ppm) in certain areas (i.e., hot spots) of the estuary. At a depth of 24 to 36 inches, most of the estuary sediments are below 10 ppm, except for the isolated areas. In the lower harbor/bay area, contamination is more widely distributed but in lower concentrations than in the estuary, ranging from non-detect to 100 ppm, with more contaminated areas coinciding with combined sewer outfalls. Numerous field studies and numerical transport modeling indicate that PCB contamination in New Bedford Harbor can be attributed to transport and deposition from the more highly contaminated sediment in the estuary.

Sediments in the estuary and harbor are also contaminated with heavy metals (i.e., cadmium, copper, lead, and chromium) from past industrial plating and textile dyeing discharges. These metals, like the PCB contamination, are also present in the greatest concentrations in the top foot of sediment, decreasing with depth. Total metals concentrations (i.e., cadmium, copper, lead, and chromium) throughout the estuary and harbor range from non-detect to greater than 5,000 ppm. High concentrations coincide with the location of industrial or combined sewer outfall discharge pipes. Metals concentrations decrease with distance from the upper harbor to the outer bay.

Following identification of PCBs in New Bedford Harbor and the Acushnet River Estuary, numerous field sampling programs were conducted; these data were compiled by EPA. Under contract to EPA, a fast-track Feasibility Study (FS) was conducted by NUS Corporation (NUS) in 1984 to address contamination in the upper estuary. In response to comments and concerns raised as a result of this FS, EPA resolved to conduct further studies to better characterize the site and answer the comments and concerns. These studies included an engineering feasibility study of dredging and dredged material disposal alternatives and a pilot study of dredging and disposal by the U.S. Army Corps of Engineers; wetland assessments by Sanford Ecological Services, Inc., and IEP, Inc.; and a sediment transport and food chain model by Battelle Pacific Northwest Laboratories and HydroQual, Inc., respectively. In 1986, Ebasco Services, Inc., was contracted to prepare an FS under the EPA REM III Program that would incorporate the studies with the work conducted by NUS, and provide EPA with a range of alternatives to remediate PCB and metals contamination in New Bedford Harbor.

In 1989, a 5-acre area, known as the Hot Spot and containing 45 percent of the total PCB mass in New Bedford Harbor, was designated as an operable unit by EPA Region I. This approach enabled EPA to proceed with a response action on a discrete, well-defined area of the site before selecting an overall remedial action. An FS of remedial alternatives for the Hot Spot was completed in July 1989, and a Record of Decision for the operable unit was signed in April 1990.

This document presents a range of overall remedial actions to address potential threats to public health and the environment caused by PCB and heavy metals contamination in the sediments and water column of the estuary (excluding the Hot Spot) and the lower harbor/bay. These actions were developed in response to the remedial action objectives, which consider the contaminants and media of interest, exposure pathways, and preliminary remediation goals.

Public health and ecological risk assessments were developed to determine the risks associated with contaminant exposure in the estuary and the lower harbor/bay.

Public health risks in excess of the state requirements and EPA guidance were associated with direct contact and incidental ingestion of sediments and ingestion of biota. These risks were attributed primarily to PCB exposure; however, concentrations of lead in shoreline sediments and biota were associated with elevated noncarcinogenic risks. Aquatic organisms in New Bedford Harbor were considered at significant risk primarily due to exposure to PCBs. Some risk was associated with exposure to metals; however, it was considered negligible compared to the risks due to PCBs.

A Target Clean-up Level (TCL) of 10 ppm PCB in sediment was developed as the remedial action objective for the estuary and the lower harbor/bay. This residual PCB concentration provides an adequate level of protection to public health against direct contact and incidental ingestion of sediment exposure to PCBs. In addition, the 10-ppm TCL will result in a reduction of PCB concentrations in biota. The TCL is considered a technically feasible level to attain.

Although significant reduction in risks to most aquatic organisms should be achieved with the 10-ppm sediment TCL, some residual risk to marine fish is predicted. However, the severe ecological impacts associated with remediation of the estuary to lower sediment TCLs are considered to outweigh the benefits obtained from reduced contamination in the study area. Therefore, a 10-ppm PCB TCL was recommended.

Section 121(d) of the Superfund Amendments and Reauthorization Act and the National Contingency Plan (40 CFR Part 300) require that the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial actions comply with all federal and state applicable or relevant and appropriate requirements (ARARs). These include chemical-specific requirements, which govern the extent of site cleanup (e.g., the U.S. Food and Drug Administration limit for PCBs in seafood); location-specific requirements, which pertain to existing site features (e.g., floodplains and wetlands); and action-specific requirements, which govern the implementation of the selected site remedy (e.g., Toxic Substances Control Act requirements for disposing of PCBs).

Remedial technologies were identified for the New Bedford Harbor site consistent with the remedial action objectives, and screened according to waste- and site-limiting characteristics.

Bench- and pilot-scale studies were conducted on the treatment technologies retained, as well as a pilot-scale study on dredging and disposal technologies. The technologies and processes retained for developing remedial alternatives are shown in Figure ES-1.

A range of alternatives was developed for the estuary (EST) and the lower harbor/bay (LHB) including no-action, containment, and removal with or without treatment prior to on-site disposal. These alternatives were screened on the basis of effectiveness, implementability, and cost. The following 12 alternatives were retained for detailed analysis:

ALTERNATIVE NUMBER	ALTERNATIVE DESCRIPTION
EST-1	No action
EST-2	Capping
EST-3	Dredge/Dispose of On-site
EST-4	Dredge/Dewater/Solidify/Dispose of On-site
EST-5	Dredge/Dewater/Solvent Extract/ Dispose of On-site
EST-6	Dredge/Dewater/Incinerate/Solidify Ash/Dispose of On-site

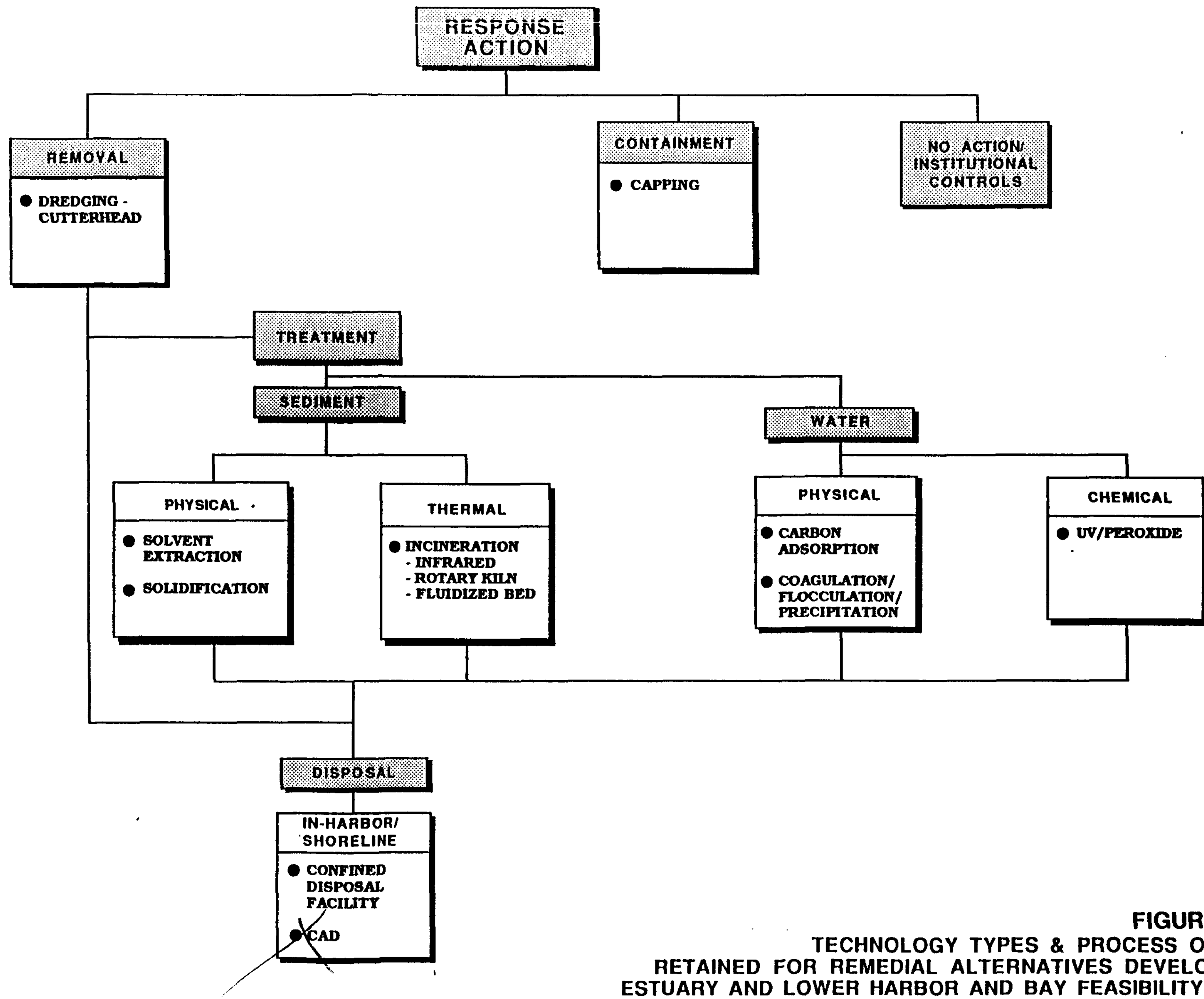


FIGURE ES-1
TECHNOLOGY TYPES & PROCESS OPTIONS
RETAINED FOR REMEDIAL ALTERNATIVES DEVELOPMENT
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

ALTERNATIVE NUMBER	ALTERNATIVE DESCRIPTION
LHB-1	No-action
LHB-2	Selective Capping
LHB-3	Dredge/Dispose of On-site
LHB-4	Dredge/Dewater/Solidify/Dispose of On-site
LHB-5	Dredge/Dewater/Solvent Extract/ Dispose of On-site
LHB-6	Dredge/Dewater/Incinerate/Dispose of On-site

These alternatives were evaluated in greater detail according to the following nine criteria defined by CERCLA:

- short-term effectiveness
- long-term effectiveness
- reduction in mobility, toxicity, or volume
- implementability
- cost
- compliance with ARARs
- overall protection of public health and the environment
- state acceptance
- community acceptance

The first seven criteria were also used to evaluate the alternatives relative to one another in the comparative analysis of alternatives. Comparative costs of the remedial alternatives for the estuary and lower harbor/bay are shown in Figures ES-2 and ES-3, respectively. Table ES-1 summarizes results of the detailed analysis.

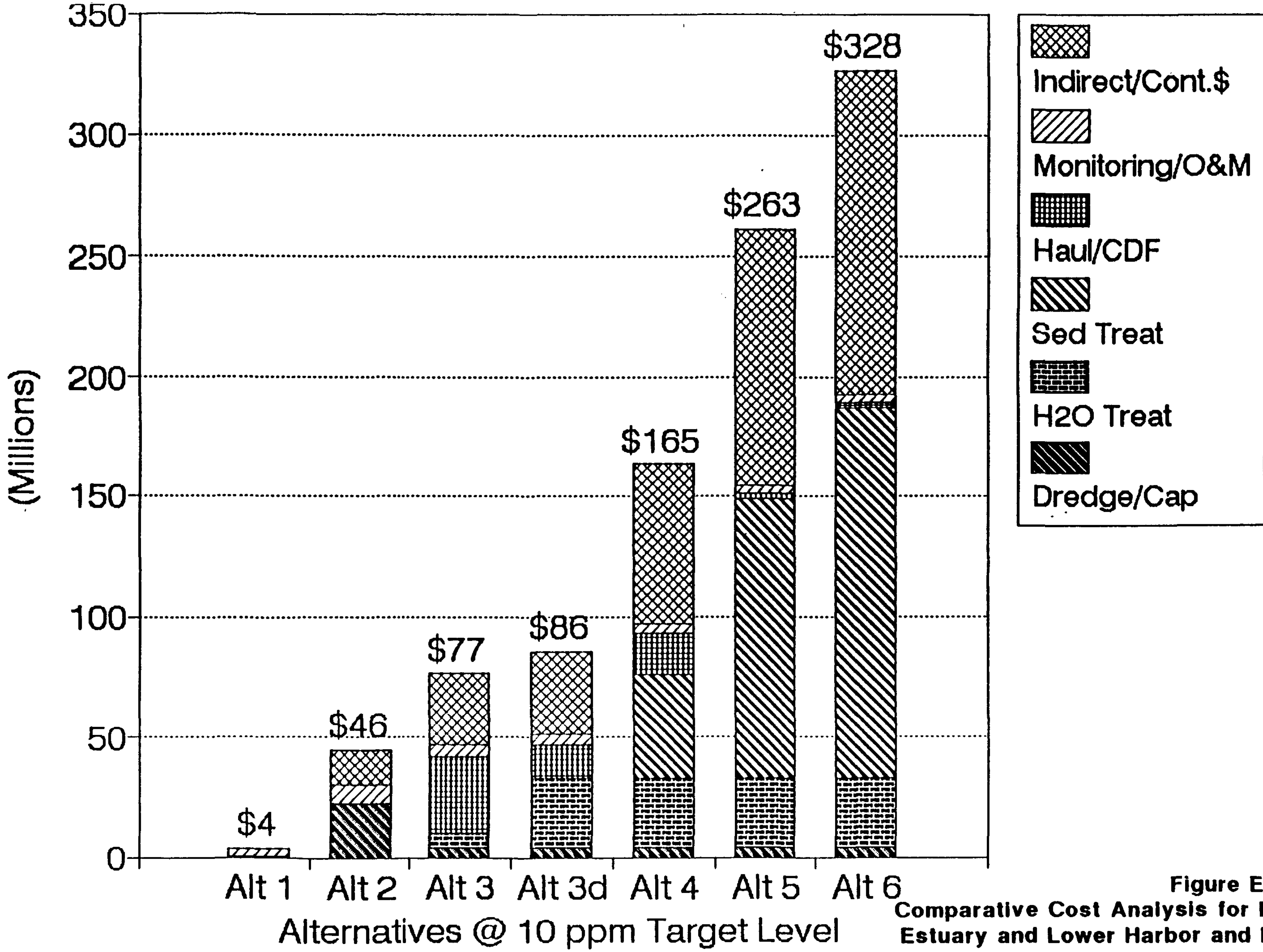


Figure ES-2
Comparative Cost Analysis for EST
Estuary and Lower Harbor and Bay
Feasibility Study
New Bedford Harbor

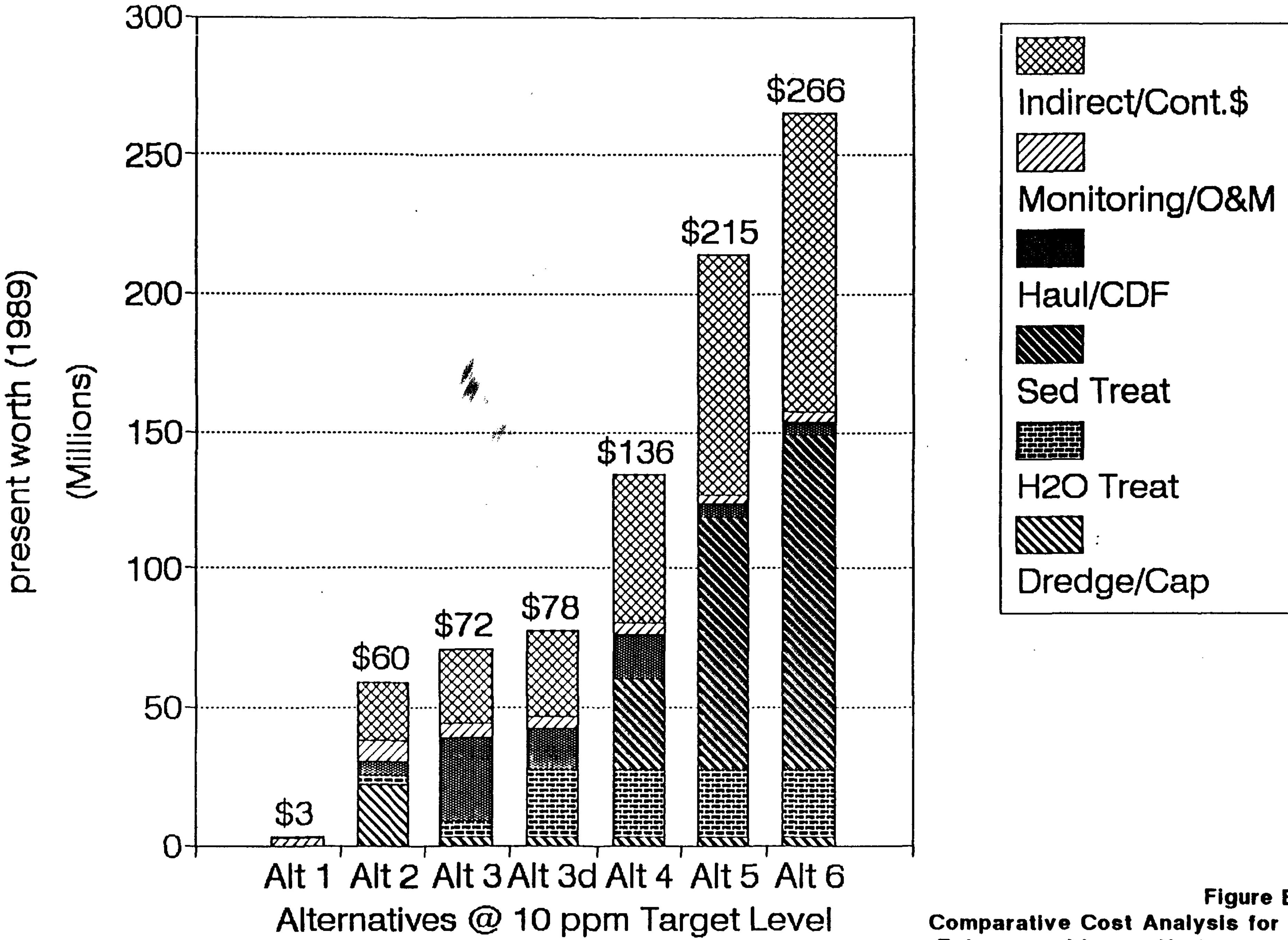


Figure ES-3
Comparative Cost Analysis for LHB Estuary and Lower Harbor and Bay Feasibility Study
New Bedford Harbor

TABLE ES-1
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-1 & LHB-1 NO-ACTION	ALTERNATIVES EST-2 & LHB-2 CAPPING	ALTERNATIVES EST-3 & LHB-3 DISPOSAL	ALTERNATIVES EST-4 & LHB-4 SOLIDIFICATION/DISPOSAL
Reduction of Toxicity, Mobility, or Volume	No reduction in toxicity, mobility, or volume because no remedial action is employed.	No reduction in mobility or toxicity. May cause an increase in volume of contaminated sediment.	Reduction in mobility or toxicity. Volume will increase if the sediment is not dewatered prior to disposal.	Reduction in mobility of the contaminants. No reduction in toxicity. Volume increased by solidification.
Short-term Effectiveness				
o Time until Protection is Achieved	No reduction in public health or environmental risk is expected.	Reduction in public health risk should occur immediately after cap placement and consolidation. Time required to achieve protection of biota depends on benthic recolonization of new cap surface.	Reduction in public health risk should occur immediately after sediment removal. Significant reduction in water column concentrations and subsequent reduction biota.	Same as Alternatives EST-3 and LHB-3.
o Protection of Community during Remedial Actions	No impact to community during remedial action.	No impact to community during remedial action.	Dredge controls and air quality controls will minimize community impacts.	Same as Alternatives EST-3 and LHB-3.
o Protection of Workers during Remedial Actions	Minimal risk to workers during fence/sign installation.	Minimal risk to workers during cap placement.	Protection required against dermal contact with dredged sediments.	Protection required against dermal contact with dredged sediments and fugitive dust from dewatered sediments and solidification process.
o Environmental Impacts	No significant adverse environmental impact from fence installation.	Destruction of benthic community will occur. Sediment resuspension expected during cap construction.	Minimal environmental impact expected from dredging or construction.	Same as Alternatives EST-3 and LHB-3.
Long-term Effectiveness				
o Magnitude of Residual Risk	Significant risks remain for public health associated with direct contact of surface soils. Environmental risks would continue unmitigated.	Potential risks remain because contaminated sediments remain in place.	Slight risks remain because the contaminants are not treated.	After sediments have been solidified and disposed of on-site, there will be minimal residual risk.
o Adequacy of Controls	No direct engineering controls; fence subject to vandalism; annual monitoring and repair required.	Annual monitoring and maintenance is required. Channel maintenance and shoreline construction will be limited. Controls to limit access to the estuary may be difficult to enforce.	Confined disposal facility construction is a proven technology; annual monitoring and maintenance is required.	Solidification and confined disposal facility construction are proven technologies; annual monitoring and maintenance of the CDFs is required.

TABLE ES-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-5 & LHB-5 SOLVENT EXTRACTION	ALTERNATIVES EST-6 & LHB-6 INCINERATION
Reduction of Toxicity, Mobility, or Volume	Reduction in toxicity and mobility of PCB sediments. Volume will increase if solidification is employed to prevent metal leaching.	Reduction in toxicity and mobility of PCB sediments. Volume also reduced unless ash is solidified to prevent metals leaching.
Short-term Effectiveness		
o Time until Protection is Achieved	Same as Alternatives EST-3 and LHB-3.	Same as Alternatives EST-3 and LHB-3.
o Protection of Community during Remedial Actions	Same as Alternatives EST-3 and LHB-3.	Same as Alternatives EST-3 and LHB-3.
o Protection of Workers during Remedial Actions	Protection required against dermal contact with dredged sediments and fugitive dust from dewatered and treated sediments.	Protection required against dermal contact with dredged sediments and fugitive dust from dewatered sediments and ash.
o Environmental Impacts	Same as Alternatives EST-3 and LHB-3.	Same as Alternatives EST-3 and LHB-3.
Long-term Effectiveness		
o Magnitude of Residual Risk	After sediments have been treated and solidified (if needed), there will be minimal residual risk.	After sediments have been incinerated and the ash solidified (if needed), there will be minimal risk associated with the treated sediments.
o Adequacy of Controls	Treatment by solvent extraction is expected to produce a treated sediment that will not need long-term control.	Incineration is a proven technology; no long-term management of treatment residuals required.

TABLE ES-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-1 & LHB-1 NO-ACTION	ALTERNATIVES EST-2 & LHB-2 CAPPING	ALTERNATIVES EST-3 & LHB-3 DISPOSAL	ALTERNATIVES EST-4 & LHB-4 SOLIDIFICATION/DISPOSAL
o Reliability of Controls	Sole reliance on fence and institutional controls to prevent exposure; high level of residual risk.	Low reliability due to potential for cap failure or disturbance.	Likelihood of CDF failure is small as long as O&M is performed. Leachate monitoring is required.	Likelihood of CDF failure is small as long as O&M is performed.
Implementation				
o Technical Feasibility	Fence/signs are easily constructed; environmental monitoring well-proven.	Technology exists to effectively cap the estuary.	CDFs easy to implement; dewatering proven during bench- and pilot-scale tests.	CDFs easy to implement; dewatering and solidification of sediments proven during bench- and pilot-scale tests.
o Administrative Feasibility	No off-site construction; therefore, no permits required.	Same as Alternatives EST-1 and LHB-1.	Same as Alternatives EST-1 and LHB-1.	Same as Alternatives EST-1 and LHB-1.
o Availability of Services and Materials	Services and materials locally available.	Services and materials readily available.	Dredge, dewatering, and CDF construction services available in the eastern U.S.	Dredge, dewatering, and solidification services available in the eastern U.S.
Cost				
Present Worth Cost	$4,092,000/$3,386,000	$46,121,000/$59,792,000	$77,434,000/$71,766,000 $86,240,000/$77,811,000 (dewatered)	$164,800,000/$135,525,000
Compliance with ARARs/TBCs				
o Compliance with ARARs	AWQC will not be attained.	AWQC will not be attained. All other ARARs will be met.	Same as Alternatives EST-2 and LHB-2.	Same as Alternatives EST-2 and LHB-2.

TABLE ES-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-5 & LHB-5 SOLVENT EXTRACTION	ALTERNATIVES EST-6 & LHB-6 INCINERATION
o Reliability of Controls	Remedy will be highly reliable due to removal of sediment causing risk.	Same as Alternatives EST-5 and LHB-5.
Implementation		
o Technical Feasibility	Solvent extraction would require special equipment and operators; treated residuals would require testing to verify treatment effectiveness; technology has been bench-tested on Hot Spot sediments.	Incineration would require special equipment and operators; treated residuals would require testing to verify treatment effectiveness; technology has been demonstrated at other sites.
o Administrative Feasibility	Same as Alternatives EST-1 and LHB-1.	Same as Alternatives EST-1 and LHB-1.
o Availability of Services and Materials	Solvent extraction equipment available from vendors but not readily. Equipment construction and pilot-scale tests may be required.	Dredge, dewatering, and mobile incinerator equipment and operators needed; services available in the eastern U.S.
Cost		
o Present Worth Cost	$262,886,000/$214,524,000	$328,166,000/$265,809,000
Compliance with ARARs/TBCs		
o Compliance with ARARs	AWQCs will not be attained. Solvent extraction will need to achieve equivalent performance standards.	Same as Alternatives EST-2 and LHB-2.

TABLE ES-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-1 & LHB-1 NO-ACTION	ALTERNATIVES EST-2 & LHB-2 CAPPING	ALTERNATIVES EST-3 & LHB-3 DISPOSAL	ALTERNATIVES EST-4 & LHB-4 SOLIDIFICATION/DISPOSAL
o Compliance with Criteria, Advisories, and Guidance	Does not meet FDA level for PCBs in fish and shellfish.	Not expected to achieve FDA level for PCBs in fish and shellfish.	Same as Alternatives EST-2 and LHB-2.	Same as Alternatives EST-2 and LHB-2.
Overall Protection of Public Health and the Environment				
o How Risks are Reduced, Eliminated, or Controlled	Risks to public health are reduced by restricting site access, environmental risks are not mitigated.	Risks to public health and the environment are reduced by minimizing contact with contaminated sediments.	Risks to public health and the environment are significantly reduced by the removal of the sediments.	Risks to public health and the environment are significantly reduced by the removal and treatment of the sediments.

TABLE ES-1
(continued)
COMPARATIVE ANALYSIS SUMMARY TABLE

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

ASSESSMENT FACTORS	ALTERNATIVES EST-5 & LHB-5 SOLVENT EXTRACTION	ALTERNATIVES EST-6 & LHB-6 INCINERATION
o Compliance with Critéria, Advisories, and Guidance	Same as Alternatives EST-2 and LHB-2.	Same as Alternatives EST-2 and LHB-2.
Overall Protection of Public Health and the Environment		
o How Risks are Reduced, Eliminated, or Controlled	Same as Alternatives EST-4 and LHB-4.	Same as Alternatives EST-4 and LHB-4.

12.89.22
0018.0.0

1.0 INTRODUCTION

This section provides a brief historical summary of the remedial studies conducted for New Bedford Harbor, a discussion of the operable unit approach used by the U.S. Environmental Protection Agency (EPA), and the organization of this report.

1.1 BACKGROUND

New Bedford, Massachusetts, is a port city located at the head of Buzzards Bay, approximately 55 miles south of Boston (Figure 1-1). Historically, New Bedford is nationally known for its role in the development of the whaling industry in the early 1800s. Today, the harbor is home port to one of the largest commercial fishing fleets in the U.S.

In 1976, EPA conducted a New England-wide survey for polychlorinated biphenyls (PCBs) (EPA, 1976). During this survey, PCB contamination was detected in various locations throughout New Bedford Harbor. Further investigation identified two electrical capacitor manufacturers, Aerovox Corporation (Aerovox) and Cornell-Dubilier Electronics Corporation (Cornell-Dubilier), as major users of PCBs from the time operations commenced in the late 1940s until 1977, when EPA banned the use of PCBs. These industries discharged wastewaters containing PCBs directly into New Bedford Harbor and indirectly via the municipal wastewater treatment system (EPA, 1976).

Field studies conducted in the late 1970s and early 1980s showed PCB concentrations in marine sediment over a 985-acre area to range from a few parts per million (ppm) to over 100,000 ppm. Portions of western Buzzards Bay are also contaminated with sediment PCB concentrations in excess of 50 ppm. Water-column concentrations were found in excess of federal ambient water quality criteria (AWQC) (i.e., 30 parts per trillion, based on chronic impacts to marine organisms). Fish and shellfish PCB concentrations were found in excess of the U.S. Food and Drug Administration (FDA) tolerance limit (i.e., 2 ppm) for edible tissue. In addition to PCBs, heavy metals (notably cadmium, chromium, copper, and lead) were found in sediment in concentrations ranging from a few ppm to over 5,000 ppm.

As a result of the widespread PCB contamination and the accumulation of PCBs in marine biota, the Massachusetts Department of Public Health established three fishing closure areas in September 1979 (Figure 1-2). These closures are still in effect. Area I is closed to all fishing (i.e., finfish, shellfish, and lobsters). Area II is closed to the taking of lobsters and bottom-feeding finfish (i.e., eel, flounder, scup, and tautog). Area III is closed to lobstering only. Closure of the New Bedford Harbor and upper Buzzards Bay area to lobstering

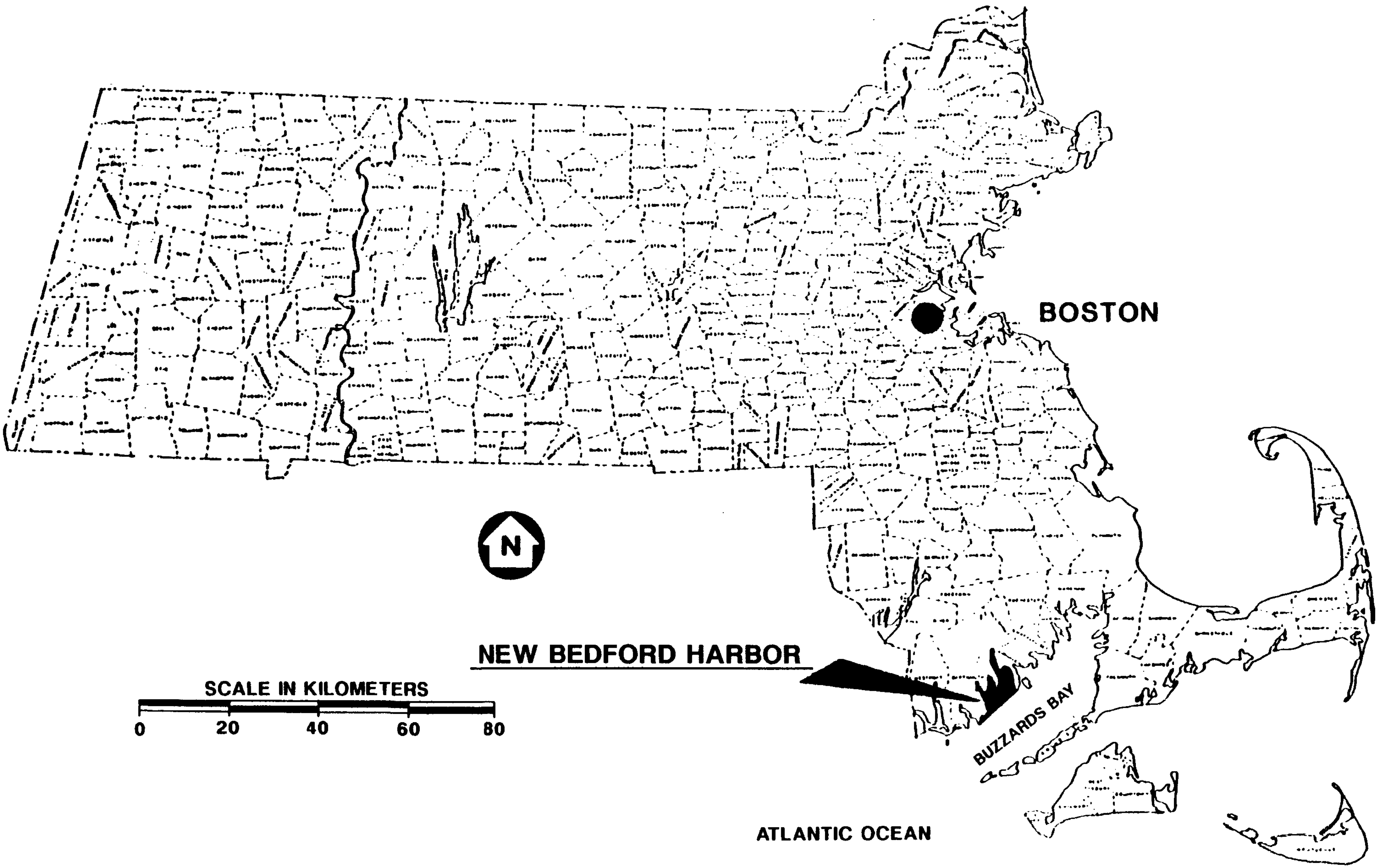


FIGURE 1-1
HARBOR LOCATION MAP
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

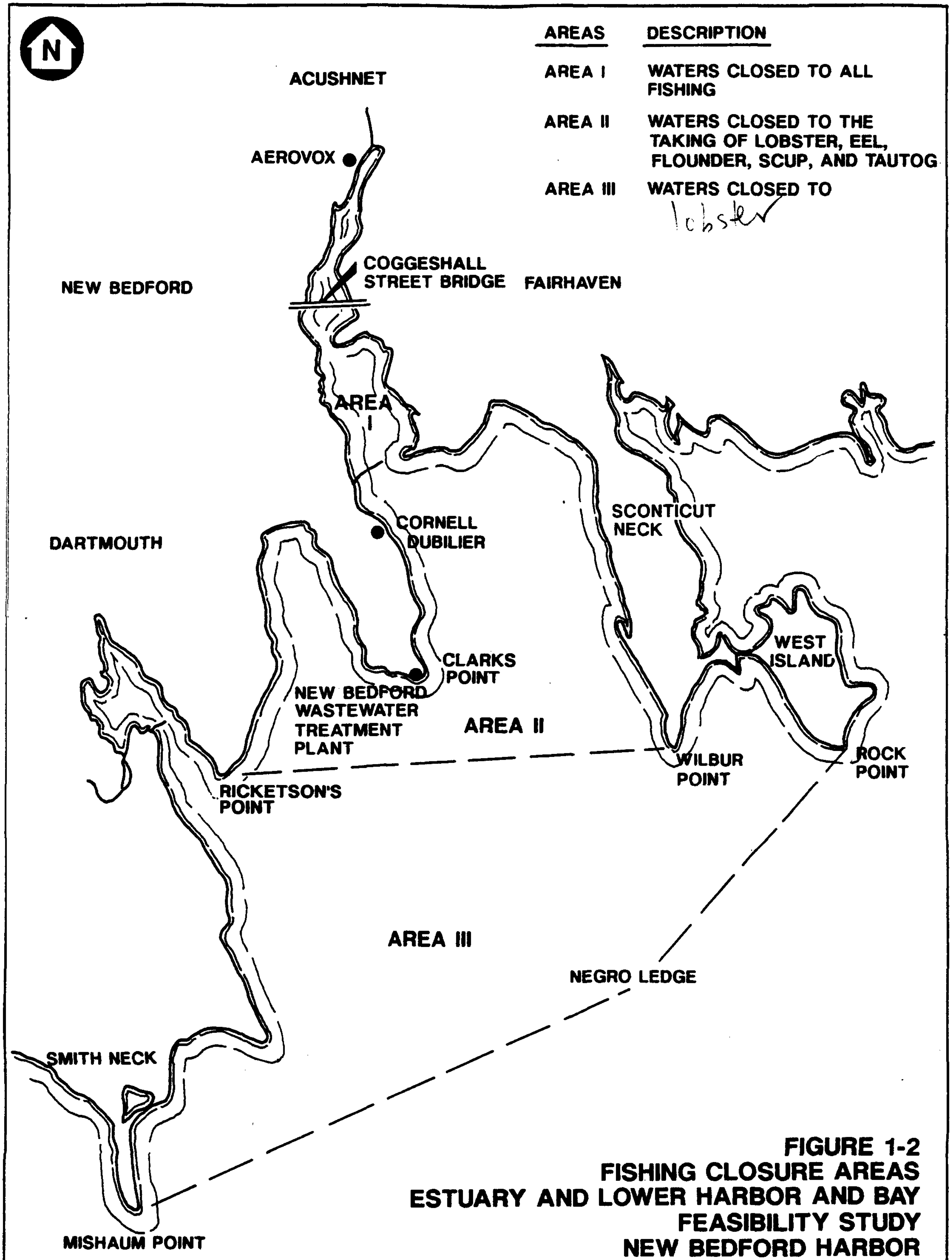


FIGURE 1-2
FISHING CLOSURE AREAS
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-22

has resulted in the loss of approximately 18,000 acres of productive lobstering ground.

In July 1982, New Bedford Harbor was added to the EPA Superfund National Priorities List (NPL), where it is currently listed in Group 2 as Site No. 76. New Bedford Harbor is the number one priority site in Massachusetts and was selected by the state in accordance with Superfund provisions. Following the NPL listing, EPA Region I initiated a comprehensive assessment of the PCB problem in the New Bedford area in August 1982. The assessment included sampling at the New Bedford and Sullivan's Ledge landfills; an areawide ambient air monitoring program; a sediment PCB profile for the Acushnet River and the harbor; biota sampling in the estuary, harbor, and bay; and a study of sewer system contamination. Results of this assessment were presented in a Remedial Action Master Plan (RAMP) for the site in May 1983 (Roy F. Weston, Inc., 1983). The RAMP included recommendations for studies to further delineate the contamination problems.

Concurrent with the assessment leading to the RAMP, EPA compiled a data base of sampling and analytical results of previous studies in the New Bedford Harbor and Buzzards Bay area. The final report on this data collection effort was issued by EPA in August 1983 (Metcalf & Eddy, 1983).

In 1983, NUS Corporation (NUS) prepared a work plan that included plans for a Feasibility Study (FS) of remedial action alternatives for the contaminated mudflats and sediment of the Acushnet River Estuary, north of the Coggeshall Street Bridge. This study was requested by EPA and the Commonwealth of Massachusetts because the levels of PCBs and heavy metals in these locations appeared to pose a near-term risk to public health, public welfare, and the environment. In October 1983, NUS received authorization to proceed with the FS for the upper estuary.

Upon completion of the upper estuary FS in August 1984, EPA sought public review and comment on the following five clean-up options:

- channeling of the Acushnet River north of the Coggeshall Street Bridge and capping of contaminated sediment in the remaining open water areas

- dredging of contaminated sediment and disposal in a partially lined confined disposal facility (CDF) located along the eastern shore in the northern part of the estuary

- same as the previous option, except that the CDF would be lined on the bottom as well as on the sides

- dredging of contaminated sediment and disposal in a nearby upland containment site (no site was identified as available at that time)

- dredging of contaminated sediment to an elevation well below the depth of contamination; contaminated dredged material would be placed in the bottom of the excavated cell and covered with a layer of clean sediment; the bottom of the upper estuary would be returned to its original elevation (disposal of contaminated sediment in subaqueous cells is termed confined aquatic disposal [CAD])

EPA received extensive comments on the options from other federal, state, and local officials; potentially responsible parties (PRPs); and the general public. Many of the comments concerned the adequacy of available dredging techniques and potential impacts of dredging on the harbor due to resuspension of contaminated sediment. The potential release of contaminated water (i.e., leachate) from an unlined disposal site was another issue of concern.

In attempting to respond to these comments, EPA determined it was necessary to conduct additional studies before choosing a clean-up method for the upper estuary. The focus of the proposed additional studies would be the feasibility of dredging and disposing of contaminated sediment. EPA asked dredging and disposal experts from the U.S. Army Corps of Engineers (USACE) to design and conduct these studies. In response to EPA's request, USACE conducted bench- and laboratory-scale studies, which comprised its Engineering Feasibility Study (EFS) of dredging and dredged material disposal alternatives for the Acushnet River Estuary (Averett and Francingues, 1988). Components of the EFS include (1) numerical modeling of sediment and contaminant transport during dredging; (2) studies of estuary sediment characterization, leachate and surface runoff from CDFs, subaqueous capping, solidification/stabilization (S/S) technologies, and settling and chemical clarification; and (3) conceptual designs of CDFs and CAD areas. The EFS was subsequently expanded to include a pilot study of dredging and disposal alternatives, which was conducted in New Bedford Harbor during the late fall and winter of 1988-1989.

In August 1986, Ebasco Services, Inc. (Ebasco) prepared a work plan to complete the FS for the entire New Bedford Harbor site under the REM III Superfund Program (Ebasco, 1986; and E.C. Jordan Co./Ebasco, 1986). Along with development of additional remedial alternatives for the site, the proposed scope of work included incorporating previous work conducted by NUS and the EFS and pilot study being conducted by USACE.

This FS was conducted for New Bedford Harbor by E.C. Jordan Co. (Jordan) under contract to Ebasco (EPA Contract No. 68-01-7250; Work Assignment No. 04-1L43). The goal of this study was to present EPA with a range of remedial alternatives to address the cleanup of PCBs and metals in New Bedford Harbor.

The New Bedford Harbor FS is divided into three geographical study areas: the Hot Spot Area, the Acushnet River Estuary, and the Lower Harbor and Upper Buzzards Bay (Figure 1-3). The Hot Spot Area is an approximate 5-acre area located along the western bank of the Acushnet River, directly adjacent to the Aerovox facility. A more detailed map of this area is shown in Figure 1-4. Sediment PCB concentrations in this area range from 4,000 to more than 100,000 ppm. Total sediment metals (i.e., cadmium, chromium, copper, and lead) concentrations range from below detection to approximately 4,000 ppm.

The Acushnet River Estuary is an area of approximately 187 acres at +4 feet mean low water (MLW), extending from the Wood Street Bridge to the north, to the Coggeshall Street Bridge to the south (see Figure 1-4). Sediment PCB concentrations in this area (excluding the Hot Spot Area) range from below detection to approximately 4,000 ppm. Total metals concentrations in sediment range from below detection to more than 5,000 ppm.

The Lower Harbor area consists of approximately 750 acres extending from the Hurricane Barrier, north to the Coggeshall Street Bridge. Sediment PCB concentrations range from below detection to more than 100 ppm. Total metals concentrations in sediment range from below detection to approximately 3,000 ppm.

The Upper Buzzards Bay portion of the FS study area extends from the Hurricane Barrier to the southern boundary of Fishing Closure Area III, an area of approximately 18,000 acres (see Figure 1-2). Sediment PCB concentrations in this area range from below detection up to 100 ppm in localized areas along the New Bedford shoreline near combined sewer and stormwater outfalls. The latter areas, comprising a few acres, will be evaluated for potential remediation as part of the FS for the estuary and the lower harbor/bay.

1.2 PURPOSE AND APPROACH

1.2.1 Operable Units for the New Bedford Harbor Feasibility Study

[Paragraph on EPA's rationale for operable unit approach; Source - Responsiveness Summary for Hot Spot FS]

In the spring of 1989, EPA Region I divided the New Bedford Harbor FS into two operable units: the Hot Spot Area and the estuary and lower harbor/bay.

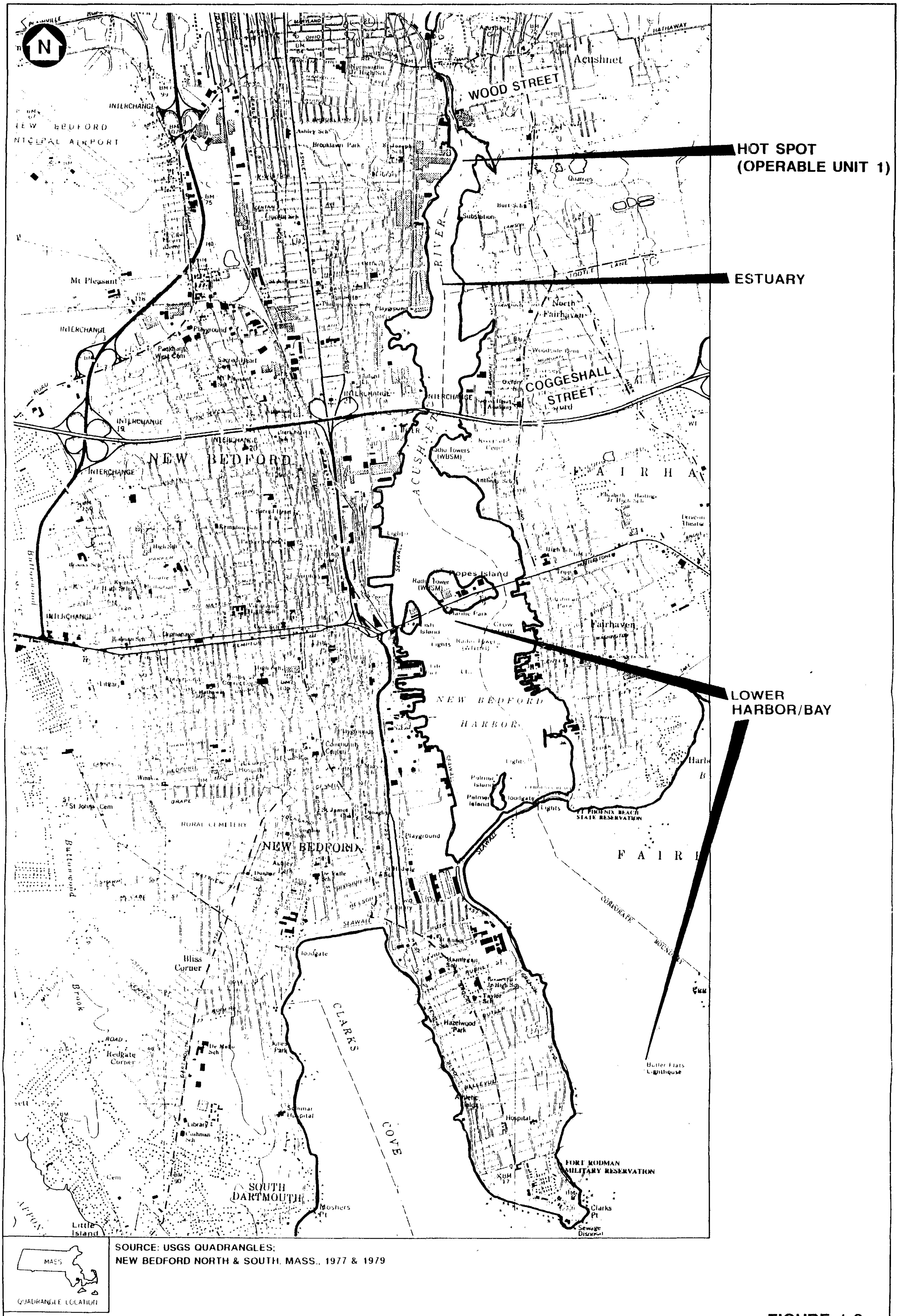
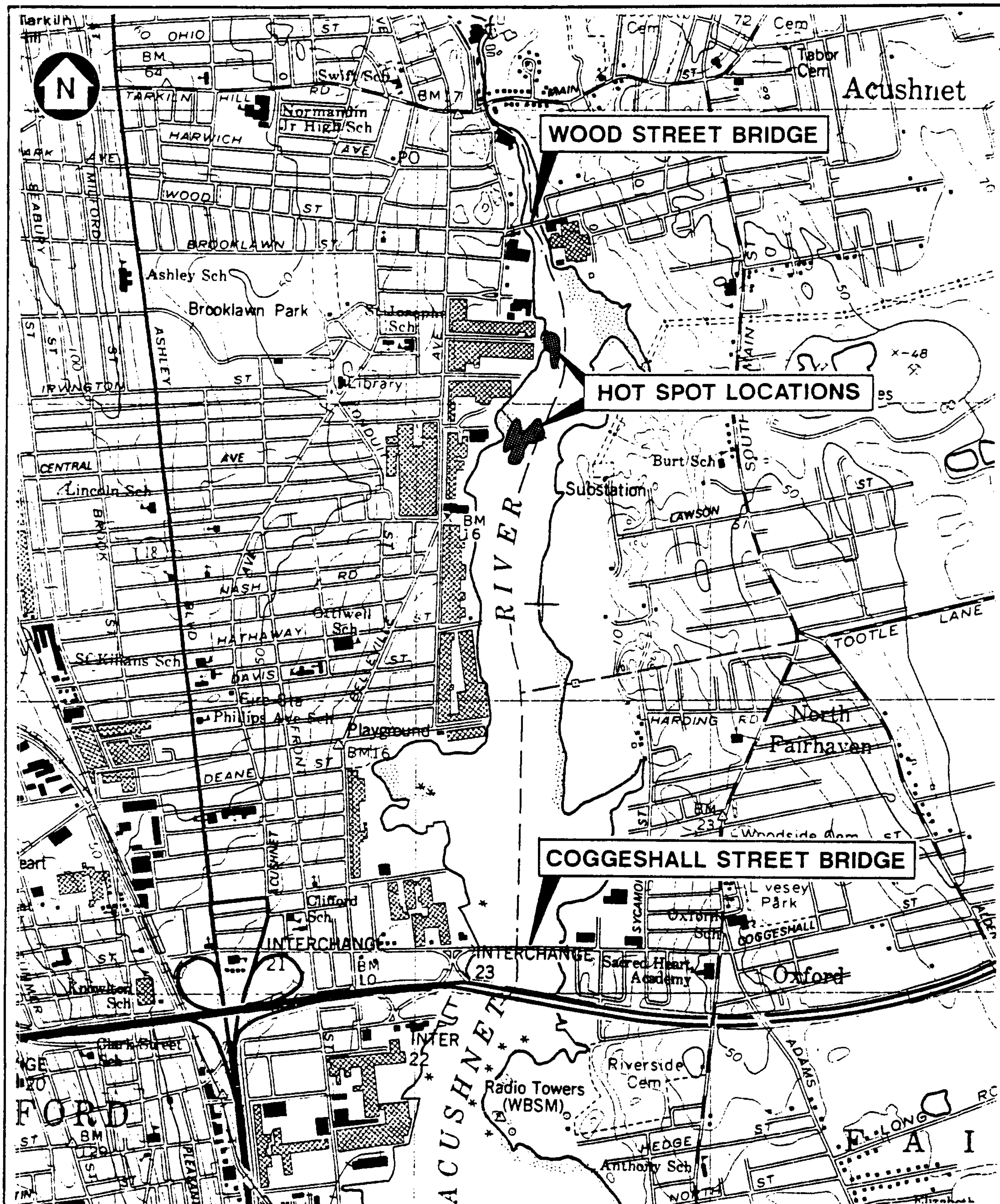


FIGURE 1-3
SITE LOCATION MAP
ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR



SOURCE: USGS MAP NEW BEDFORD, MASS (NORTH & SOUTH) 1979

FIGURE 1-4
UPPER ACUSHNET RIVER
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

1.2.2 The Hot Spot Operable Unit

The 5-acre Hot Spot Area was chosen as an operable unit because it is a discrete, well-defined area that contains approximately 45 percent of the total PCB mass in sediment within the Acushnet River Estuary and New Bedford Harbor. An FS of remedial alternatives for the Hot Spot Area was prepared and submitted to EPA Region I in July 1989 (E.C. Jordan Co./Ebasco, 1989b). The Hot Spot Area FS presented the following four remedial options, which had been evaluated in detail:

- no action
- dredging of contaminated sediment in the Hot Spot Area; incineration of the sediment with solidification as an optional treatment step to immobilize residual metals; disposal of the treated residue in an unlined shoreline CDF
- same as the previous option, but using solvent extraction as the primary treatment process
- dredging of contaminated sediment in the Hot Spot Area; solidification of the sediment and off-site disposal in a federally permitted facility

In August 1989, EPA Region I issued a proposed plan in which it selected the dredging and incineration alternative for the Hot Spot Area because, compared to the other alternatives evaluated, it offered the highest degree of contaminant destruction. The alternative is a highly reliable, well-proven technology for the treatment of organic waste, and it is a permanent remedy (EPA, 1989).

The remedial action chosen for the Hot Spot Area is an interim remedy and will be consistent with a remedial action selected for the estuary and lower harbor/bay operable unit, which will complete the overall remediation of the New Bedford Harbor site.

1.2.3 The Estuary and Lower Harbor/Bay Operable Unit

The Acushnet River Estuary (excluding the Hot Spot Area) and the Lower Harbor/Upper Buzzard's Bay comprise the second operable unit for the New Bedford Harbor site. This report is the FS of the remedial alternatives for the estuary and the lower harbor/bay areas. The purpose of the FS is to present EPA with a range of remedial alternatives that specifically address protection of public health and the environment from PCBs and metals in the estuary and lower harbor/bay sediment.

The estuary and lower harbor/bay FS was conducted in accordance with the following legislation and guidance governing hazardous waste remediation:

- o National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule (FR 47912, November 1985)
- o Superfund Amendments and Reauthorization Act (SARA) of 1986
- o Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Interim Final (EPA Office of Solid Waste Emergency Response [Oswer] Directive 9355.3-01; October 1988)
- o National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule (FR 8666, March 1990)

The remedial alternative selected for the estuary and lower harbor/bay will be consistent with the remedial strategy selected for the Hot Spot Area. The combination of the two will achieve the established Target Clean-up Levels (TCLs) for the overall New Bedford Harbor site.

1.3 REPORT ORGANIZATION

Section 2.0 presents the physical and chemical characterization of the estuary and the lower harbor/bay areas. The spatial extent of PCB and metals contamination is discussed, including the methodology used to calculate the area and volume of PCB contamination in the estuary and lower harbor/bay based on TCLs. Section 2.0 also discusses results of the hydrodynamic and sediment contaminant transport model conducted by Battelle Pacific Northwest Laboratories (Battelle) and the food chain model conducted by HydroQual, Inc. (HydroQual).

Section 3.0 summarizes the methodologies and results of the public health and environmental baseline risk assessments conducted for the overall New Bedford Harbor site.

Section 4.0 discusses applicable or relevant and appropriate requirements (ARARs) for the New Bedford Harbor site, followed by a summary of the sediment TCLs for protection of public health and environmental biota. This discussion forms the basis for the development of sediment TCLs, also presented in Section 4.0, that were selected for New Bedford Harbor and used in this FS for the detailed evaluation of remedial alternatives (Section 7.0). Section 4.0 concludes with a discussion of the remedial action objectives developed for the estuary and the lower harbor/bay areas. These objectives were used as guidelines for the subsequent selection of remedial technologies and the development and evaluation of remedial alternatives.

Section 5.0 presents the identification, screening, and detailed evaluation of remedial technologies for New Bedford Harbor. Section 5.0 is an inventory of applicable technologies that can be assembled into alternatives capable of meeting the remedial action objectives. Section 5.0 includes discussions and results of numerous technology studies conducted in support of the New Bedford Harbor Superfund project. Section 5.0 concludes with a summary of the remedial technologies considered applicable for the estuary and the lower harbor/bay.

Section 6.0 describes the development and screening of remedial alternatives for the estuary and the lower harbor/bay areas. A range of alternatives is developed as prescribed by SARA and EPA guidance for conducting FSs under CERCLA. The alternatives are screened on the basis of effectiveness, implementation, and cost. Remedial alternatives remaining after the screening are carried forward for detailed evaluation.

Section 7.0 presents the detailed evaluation of remedial alternatives for the estuary and the lower harbor/bay areas. Each alternative contains a conceptual design and an evaluation using the nine criteria prescribed by CERCLA Remedial Investigation/FS guidance (Interim Final, October 1988) and the proposed NCP (FR 51506 (e)(9)). Some of the alternatives are similar enough to be discussed in the same subsection, which is done where possible.

Section 8.0 presents a comparative analysis of the remedial alternatives to evaluate the performance of each alternative relative to each specific criterion.

2.0 SITE DESCRIPTION

The New Bedford Harbor site has been the subject of numerous studies, which are cited in the Administrative Record. This section draws from and references many of these studies to describe the site history and to present the extent of contamination and potential transport and fate of PCB-contaminated sediment in the upper estuary and the lower harbor/bay areas.

2.1 BACKGROUND

Descriptions of the site history and socioeconomic setting, as well as details of the hydrologic and subsurface conditions in New Bedford Harbor, have been presented in detail in previously published reports (Weaver, 1982; and NUS, 1984a and 1984b). The following subsections present a general description of the New Bedford Harbor site.

2.1.1 Site Topography and Bathymetry

New Bedford Harbor is an estuary of the Acushnet River (see Figure 1-4). The Acushnet River drains a small basin of approximately 28 square miles above the Saw Mill Dam, located 0.4 mile above the Wood Street Bridge. The Wood Street Bridge is the approximate upstream limit of tidal influence. New Bedford Harbor is about 3.8 miles in length, extending from the Wood Street Bridge to the north, to the Hurricane Barrier to the south. The harbor can be subdivided into two major areas: the upper harbor or the Acushnet River Estuary; and the lower harbor, which opens into the upper reaches of Buzzards Bay.

2.1.1.1 Acushnet River Estuary

The Acushnet River Estuary is an area of approximately 187 acres (at +4 feet MLW) extending northward from the Coggeshall Street Bridge to the Wood Street Bridge, a distance of about 1.5 miles (see Figure 1-4). The estuary is bordered by New Bedford to the west and Acushnet to the east. The western side of the estuary is an active commercial zone for the City of New Bedford, consisting of light industrial and retail businesses. The eastern side of the estuary consists of an extensive wetlands area extending south from just below the Wood Street Bridge and the Acushnet Manufacturing Company, to within a few hundred yards of the Coggeshall Street Bridge. The wetlands along the eastern shore are mainly high saltmarsh and tidal flats encompassing approximately 70 acres of the estuary area (measured from an elevation of +4 feet MLW based on the USACE grid-coordinate system).

Water depths associated with the estuary vary considerably. At MLW, the greatest water depth is approximately 18 feet at the Coggeshall Street Bridge. Following the center of the river channel north toward the Wood Street Bridge, the water depth drops to 6 feet, decreasing to 2 feet at the head of the estuary. Current velocities of about 1.83 meters per second (m/sec) maximum ebb, 0.91 m/sec maximum flood, 0.52 m/sec average ebb, and 0.34 m/sec average flood have been measured at the Coggeshall Street Bridge (EPA, 1983b). Salinities in the estuary range from 26 to 30 parts per thousand (ppt), and have been reported as low as 12 ppt at the surface after a heavy rain (EPA, 1983b).

The sediments in the estuary are predominantly organic silts and marine clays. Grain-size analysis has shown that 40 to 80 percent of the sediments pass through a U.S. Standard No. 200 sieve. Total organic carbon (TOC) content ranges from 17.1 to 140.3 ppt, with a mean value of approximately 89.4 ppt. Moisture content of the sediments ranges from 30 to 60 percent by weight (GCA Corporation, 1983).

2.1.1.2 Lower Harbor

The lower harbor is an area of approximately 750 acres extending northward from the Hurricane Barrier to the Coggeshall Street Bridge, a distance of about 2.3 miles. The City of New Bedford borders the western side of the harbor, while the Town of Fairhaven borders the east. Both sides of the lower harbor provide extensive berthing and servicing facilities for the recreational boating and commercial fishing fleets. The eastern corner of the lower harbor adjacent to the Hurricane Barrier is lined with shorefront residences.

Water depths typically range from 6 to 12 feet except in areas adjacent to the federal- and state-maintained shipping channel, which is 30 to 50 feet deep. Current speeds are usually less than 0.32 m/sec. The lower harbor appears to be vertically well mixed with generally 1- to 2-ppt top-to-bottom differences in salinity (Teeter, 1988).

Sediments in the lower harbor are predominantly silty sands; that is, 60 percent sands within the upper reaches of the lower harbor, increasing to 90 percent sands in a seaward direction.

2.1.1.3 Upper Buzzards Bay

The portion of Buzzards Bay included within the New Bedford Harbor Superfund site extends from Mishaum Point on Smith Neck, to Negro Ledge to Rock Point on West Island. However, for the purposes of potential remedial action, the area extending from the Hurricane Barrier south to the Butler Flats Lighthouse comprises the bay portion of this study. The extent of contamination in this area is discussed in greater detail in Subsection 2.2.3.

Water depths in the bay vary from tidal flats near shore to approximately 35 feet in the shipchannel. Sediments are predominantly sand.

2.1.2 Source of Contamination

PCBs were used from the early 1940s until the late 1970s by two manufacturing facilities located in New Bedford: Aerovox, located on Belleville Avenue on the western bank of the Acushnet River Estuary; and Cornell-Dubilier, located on Rodney French Boulevard approximately 0.4 mile south of the Hurricane Barrier on the western shore of upper Buzzards Bay.

The Aerovox facility used PCBs from 1947 to 1978 as impregnation fluids in the manufacture of electrical capacitors for applications ranging from fluorescent light ballasts to electronic equipment. Aroclor 1242, purchased from Monsanto Corporation, was used in substantial quantities until 1972 when Aroclor 1016 was introduced, completely replacing Aroclor 1242 as the impregnation fluid. Aroclors 1254 and 1252 were also used in smaller quantities. Between January 1973 and December 1975, more than four million pounds of PCB impregnation fluid was used at the Aerovox facility (Weaver, 1982).

The discharge of wastewater containing PCBs from the Aerovox facility has been documented by EPA (EPA, 1976). In addition to direct discharge of PCBs, waste capacitors have been disposed of in the estuary, and are considered a source of PCB contamination in the Hot Spot Area sediment (Weaver, 1982).

The Cornell-Dubilier facility also used PCBs from 1941 to 1977 in the manufacture of electrical capacitors for use in consumer products. Aroclor 1242 was used before 1971; from 1971 to 1977, Aroclor 1016 was used. Over three million pounds of Aroclor 1016 and approximately 22,000 pounds of Aroclor 1254 were used by Cornell-Dubilier from 1971 to 1975 (Weaver, 1982).

Cornell-Dubilier discharged process wastewaters to the municipal wastewater treatment plant via the City of New Bedford sewers. Wastewaters also were discharged to Buzzards Bay via combined storm sewer overflows. The presence of PCBs in these conduits downstream of the Cornell-Dubilier facility has been verified in numerous studies (Weaver, 1982). The areas of elevated sediment PCB concentrations in the outer bay coincide with the approximate locations of these combined sewer overflows, including an area surrounding the primary outfall from the treatment plant.

In addition to PCB contamination in the sediment, significant concentrations of heavy metals contamination in the sediment have been documented. The principal metal contaminants are cadmium, copper, chromium, lead, and zinc. Although point sources of these metals have not been explicitly identified, their presence has been attributed to discharges from metals plating and manufacturing and textile dyeing operations conducted in New Bedford during the last 80 years.

2.2 EXTENT OF CONTAMINATION

This subsection provides an overview of the data used to assess contamination in the estuary and the lower harbor/bay, the methods used to interpret these data, an interpretation of the PCB and inorganic (i.e., heavy metals) contamination, and determination of the area and volume of sediment that would require remediation at four different PCB TCLs.

The following sediment sampling data were used to determine the nature and distribution of PCB and inorganic contamination in New Bedford Harbor:

- U.S. Coast Guard Sediment Sampling Program (1982)
- NUS/Goldberg-Zoino Associates Harbor Grid Sampling Program (1986)
- USACE Field Investigation Team Sampling Program (1986)
- Battelle Hot Spot Sediment Sampling Program (1987)
- USACE Wetlands and Benthic Sediment Sampling Program (1988)
- USACE Hot Spot Sediment Sampling Program (1988)

These data sets were used for the estuary and the lower harbor/bay contamination assessment because of consistent sampling and analytical procedures.

The analytical data for New Bedford Harbor were acquired during a six-year period. The main focus of several of the sampling programs was to delineate the Hot Spot Area. Therefore, the data density in the remainder of the estuary and the lower harbor/bay is less than that of the Hot Spot Area. EPA believes the data sets are consistent and can be used collectively to evaluate the areas of contamination.

The focus of this FS is the estuary and the lower harbor/bay, the second operable unit for the New Bedford Harbor site. However, where necessary, references to and discussions of the Hot Spot Area (i.e., Operable Unit 1) are provided to establish continuity between the two FS reports.

2.2.1 Methodology for Data Interpretation

To determine the horizontal and vertical distribution of contamination in the estuary, PCB concentration maps were prepared from the data for three sediment depths: zero to 12 inches, 12 to 24 inches, and 24 to 36 inches. Except for the northernmost area, there was minimal contamination below 36 inches; therefore, maps were not prepared for depths below 36 inches. Sediment samples from each of the five sampling programs were marked on sample location maps for the three sediment depths. PCB concentration contour maps were developed from the corresponding sample location maps by:

- o assigning each sediment sample location the corresponding total PCB concentration (Aroclor summation)

- o developing a contamination range for contouring

- o contouring the sediment PCB concentrations to illustrate contaminant distribution

The following contouring procedure was used to delineate the horizontal distribution of contamination in the estuary. To enhance data interpretation, order-of-magnitude concentration ranges were established. As an example, the PCB ranges developed for the estuary are zero to 10 ppm, 10 to 50 ppm, 50 to 500 ppm, 500 to 4,000 ppm, and greater than 4,000 ppm. This range was developed to be consistent with the Toxic Substances Control Act (TSCA) definition of PCB-contaminated material (i.e., 50 to 500 ppm), PCB material (greater than 500 ppm), and the 4,000-ppm action level established to define the Hot Spot Area in the Hot Spot FS. Isoconcentration contours were derived by dividing the distance between sample points of different concentration ranges. For example, if the sample points differed by one range, the contour was drawn halfway between the points; for two ranges, the distance was divided into thirds, and the two contours drawn at these points. This method provides a qualitative assessment of contaminant distribution and is an appropriate method for determining PCB-contaminated sediment volume where there is adequate data density.

Adequate data density for calculating volumes using this method only exists in the Hot Spot Area. The method used for delineating sediment contamination areas and subsequent volumes in the remainder of the estuary and the lower harbor/bay is discussed in Subsection 2.2.4.

PCBs are the primary contaminant of concern in the estuary and the lower harbor/bay. New Bedford Harbor is not a pristine estuarine environment, and historically has received industrial and sanitary waste discharges. Due to these other discharges, there are elevated levels of polycyclic aromatic hydrocarbons (PAHs) and heavy metals (i.e., copper, chromium, lead, and cadmium) in the harbor sediment. The presence of and potential risks from metals contamination are discussed in the baseline risk assessment; risks from exposure to PAHs in New Bedford Harbor have been previously evaluated (E.C. Jordan Co./Ebasco, 1987f).

PAH compounds were found to be co-located with PCBs; however, the range of PAH concentrations in the upper estuary sediment was significantly lower than the range of PCB concentrations. Total PAH concentrations range from below detection limit to 930 ppm, with an average PAH sediment concentration of approximately 70 ppm. (The highest PAH concentration of 930 ppm was detected in the Hot Spot Area.) No discrete areas of elevated PAH levels were observed, suggesting that PAH contamination results from non-point sources such as urban runoff. PAH concentrations detected in the upper estuary sediment are similar to PAH concentrations detected in other urban and industrialized areas (EPA, 1982).

The relative toxicity of PAH compounds with respect to PCBs indicates that the majority of risk from exposure to sediment in the harbor will be attributed to PCBs. Because PAH compounds can be effectively treated by the technologies identified to treat the PCB contamination (see Section 5.0), methods employed to reduce PCB contamination will effectively reduce PAH contamination. However, unlike PCBs, the discharge of PAH compounds is expected to continue after remediation into the upper estuary from non-point sources. Therefore, remedial actions may not permanently reduce levels of these contaminants.

Risk from exposure to metals was evaluated in the baseline risk assessment and is summarized in Section 3.0. In addition to potential risks caused by these contaminants, metals contamination in New Bedford Harbor is a concern from an engineering perspective. Heavy metals cannot always be treated with the same treatment technologies identified for PCBs, and may serve as a future source of contamination during any disposal of treated sediment.

Subsection 2.2.2 discusses distribution of the PCB and metals contamination in the estuary. Subsection 2.2.3 presents the distribution of the PCB and metals contamination in the lower harbor/bay. Subsection 2.2.4 discusses the methodology for calculating contaminated sediment areas and volumes, and presents results of these calculations for both areas.

2.2.2 Contamination in the Estuary

This section discusses the PCB and metals contamination in the estuary.

2.2.2.1 Polychlorinated Biphenyls

Figure 2-1 is a contour map of the PCB sediment contamination in the top 12 inches of sediment. PCB contamination is more widespread in the upper 12 inches of the sediment than at other depths. The hot spot areas (i.e., contamination at levels greater than 4,000 ppm) at this depth are clearly identified, comprising a total area of 5 acres.

Sediment PCB concentrations in the 500- to 4,000-ppm range surround the Hot Spot Area and extend northward toward the Wood Street Bridge, eastward into a cove area, and southward into the estuary. The presence of PCB contamination in these areas is attributed to PCB migration from the Hot Spot Area due to tidal fluctuations and wind-driven currents. Although PCB sediment contamination is in excess of 50 ppm throughout most of the estuary, concentrations decrease significantly with increasing distance from the Hot Spot Area. Concentrations in the lower reaches of the estuary, near the Coggeshall Street Bridge, are generally below 50 ppm.

PCB contamination in the upper estuary extends into the wetlands located on the eastern side of Acushnet River. The concentration of PCBs in the wetlands area ranges from non-detect to greater than 1,000 ppm. Results of sampling conducted by Balsam Environmental Consultants, Inc. (Balsam) indicates a correlation between higher PCB concentrations (i.e., greater than 100 ppm) and the location of drainage ditches and tidal creeks (Balsam, 1989). Although there is evidence of bioaccumulation of PCBs in wetland biota, these areas continue to support a variety of plant and animal species typical of estuaries in southeastern New England, and are considered to possess high resource value (IEP, Inc., 1988).

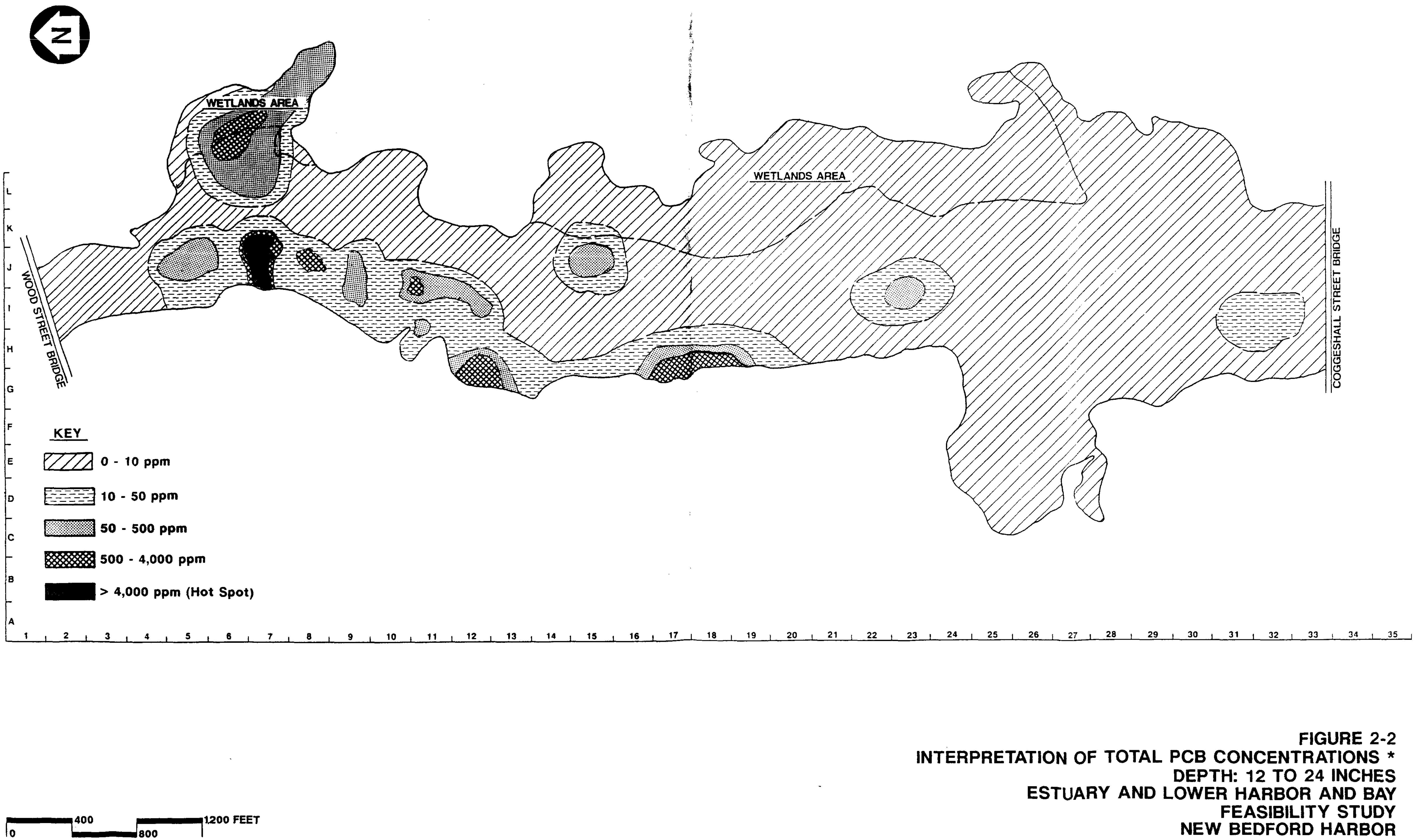
Figure 2-2 is an interpretation of sediment PCB contamination in the 12- to 24-inch depth interval. PCB contamination at this depth is substantially lower than the surface interval, and the Hot Spot Area has been reduced to the northernmost area. Sediment PCB contamination in the 500- to 4,000-ppm range is limited to pockets located in the eastern cove area, in the area below the larger Hot Spot Area, and two areas located along the western shore. These two areas are located near combined sewer overflows.

In Figure 2-3 (24- to 36-inch depth interval), most of the estuary is below the 10-ppm level, with sediment PCB concentrations below the detection level in the lower estuary. The Hot Spot at this depth is limited to a small (northernmost) area. An additional area of PCB contamination at this depth interval is located adjacent to the combined sewer overflow on the western bank midway down the estuary. Concentrations of PCBs in the sediment from this area range from 50 to 4,000 ppm.

4959-25

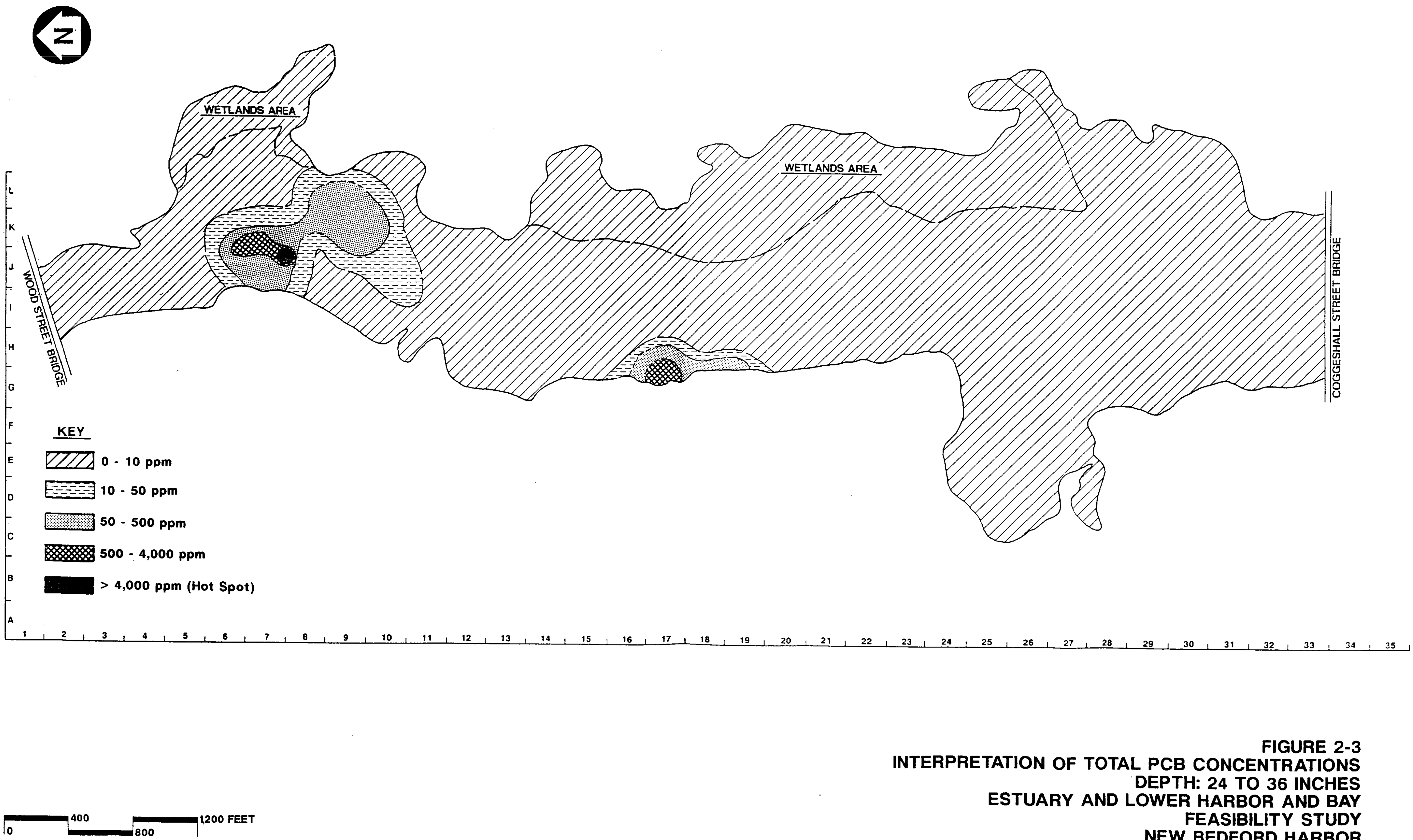
FIGURE 2-1
INTERPRETATION OF TOTAL PCB CONCENTRATIONS *
DEPTH: ZERO TO 12 INCHES
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

* SUM OF AVAILABLE AROCHLOR DATA



3959-25

FIGURE 2-2
INTERPRETATION OF TOTAL PCB CONCENTRATIONS *
DEPTH: 12 TO 24 INCHES
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR
* SUM OF AVAILABLE AROCHLOR DATA



4959-25

FIGURE 2-3
INTERPRETATION OF TOTAL PCB CONCENTRATIONS
DEPTH: 24 TO 36 INCHES
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

2.2.2.2 Metals

The contour maps in Figures 2-4 through 2-6 show total metals concentrations (i.e., cadmium, copper, chromium, and lead) in sediment at depths of zero to 12 inches, 12 to 24 inches, and 24 to 36 inches. These maps were developed in a manner similar to the PCB maps from data collected by Battelle and USACE. The four metals were selected based on prevalence in the sediment and toxicity to aquatic biota.

The metals concentration ranges illustrated in Figures 2-4 through 2-6 are different than those established for the PCB maps. The total metals concentrations were separated into four ranges: zero to 100 ppm; 100 to 1,000 ppm; 1,000 to 5,000 ppm; and greater than 5,000 ppm. These ranges were established to facilitate data interpretation and do not reflect any regulatory limits. In fact, heavy metals unlike PCBs are naturally found in sediments. Concentrations of heavy metals in the zero- to 100-ppm range may reflect natural or background conditions and not areas of contamination. Maps for each of the four heavy metals were not developed because it was determined unnecessary for data interpretation and the FS. Where details of specific heavy metals contamination were required (e.g., during the risk assessment), the associated data points are discussed separately.

Similar to PCBs, the metals concentrations are greatest in the top foot of sediment, decreasing with depth. However, the area of high metals contamination (i.e., greater than 5,000 ppm) in the estuary is not within the PCB Hot Spot Area. Metals contamination appears to be greatest in the southern cove area. This area, as well as the western shore of the estuary, is heavily industrialized. The location of the high metals-contaminated sediment appears to correlate with the location of industrial discharge and/or combined sewer overflow discharge pipes.

Elevated metals concentrations were detected throughout the top 36-inch depth of sediments. Public health risks are associated with exposure to these metals (see Section 3.0); however, the risks comprise a small component of the total risk when compared to risks associated with exposure to PCB-contaminated sediment. The presence of metals in estuary area sediment is important because many treatment technologies capable of treating the PCBs are ineffective for treating metals. For this reason, additional treatment steps may be required to treat the metals remaining in the sediment after treatment for PCBs.

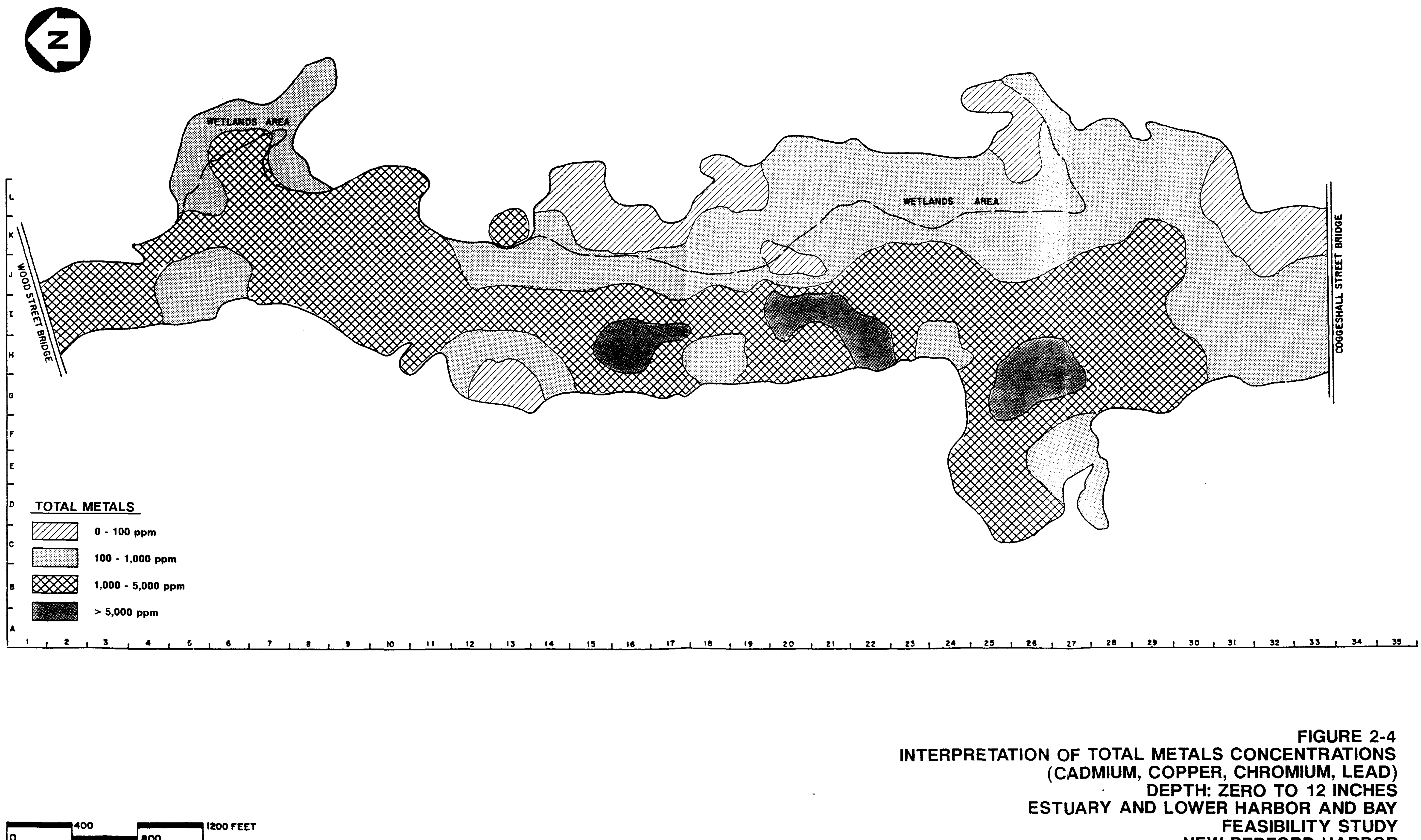


FIGURE 2-4
INTERPRETATION OF TOTAL METALS CONCENTRATIONS
(CADMIUM, COPPER, CHROMIUM, LEAD)
DEPTH: ZERO TO 12 INCHES
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

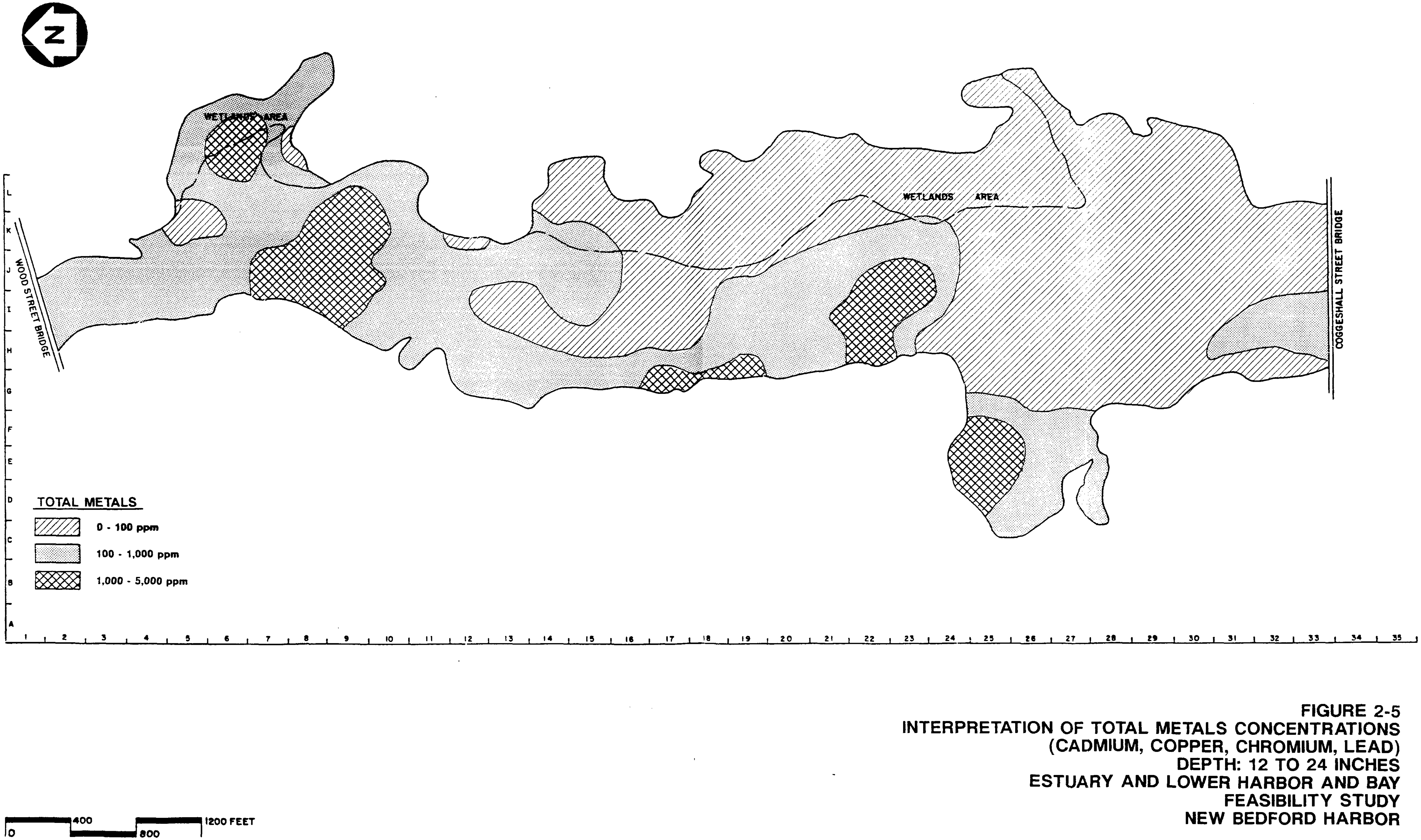


FIGURE 2-5
INTERPRETATION OF TOTAL METALS CONCENTRATIONS
(CADMIUM, COPPER, CHROMIUM, LEAD)
DEPTH: 12 TO 24 INCHES
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

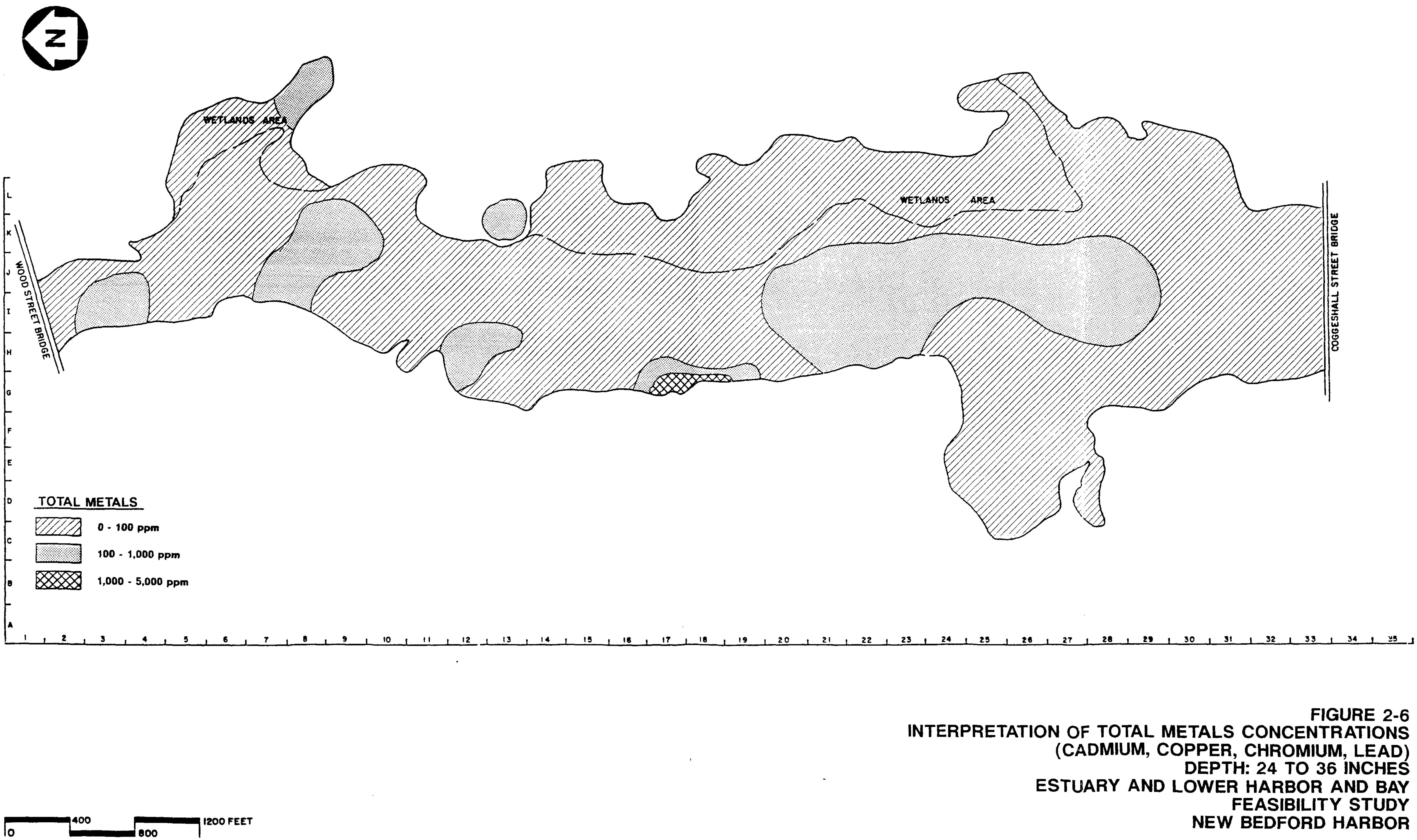


FIGURE 2-6
INTERPRETATION OF TOTAL METALS CONCENTRATIONS
(CADMIUM, COPPER, CHROMIUM, LEAD)
DEPTH: 24 TO 36 INCHES
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

2.2.3 Contamination in the Lower Harbor/Bay

2.2.3.1 Polychorinated Biphenyls

Figure 2-7 illustrates the interpretation of PCB data in the lower harbor/bay. Limited data were available for this area; most of the sampling points represent the zero- to 6-inch depth. Although the area of PCB contamination in the lower harbor/bay is more extensive than the estuary, the PCB concentrations in the sediment are markedly reduced from that of the estuary. Only one area in the lower harbor/bay had PCB concentrations exceeding 100 ppm. For this reason, the ranges of PCB concentrations used for contouring are different than those in the estuary. Five ranges were established for the lower harbor/bay to enhance data interpretation: less than 1 ppm, 1 to 10 ppm, 10 to 50 ppm, 50 to 100 ppm, and greater than 100 ppm.

Sediment PCB concentrations in the lower harbor/bay are greatest in the northern part of the harbor adjacent to the Coggeshall Street Bridge and the Route I-195 Bridge. This suggests that PCBs originating in the estuary are being transported to the lower harbor. The majority of deposition appears to occur in the northern part of the harbor between the Route I-195 and Route 6 bridges. There also appears to be an additional source in this area between the bridges, which is located off the New Bedford shore, opposite the Conrail railyard. This area was used for unloading PCBs from railroad tank cars, and is known to be contaminated with PCBs (NUS, 1986). It is suspected that runoff from this area entered storm drains and discharged into the harbor at this location.

The distribution of PCB sediment contamination between the Route 6 Bridge and the Hurricane Barrier is more random. The majority of the sediment in this area has PCB concentrations in the 1- to 10-ppm range; however, there are localized areas where PCB concentrations are less than 1 ppm and other areas that exceed 10 ppm (i.e., 10 to 50 ppm). The spotty distribution of PCB contamination may be attributed to the complicated hydrodynamics occurring within the area. Flow constrictions occurring at the bridges, the Hurricane Barrier, and near islands; tidal influence; and boat traffic within the harbor may all serve to create isolated scour and depositional areas. The primary source of PCBs for this area is believed to be from the upper estuary; however, PCB contamination from the Conrail railyard may also be a contributor.

South of the Hurricane Barrier, the most significant area of contamination is associated with the general location of the Cornell-Dubilier manufacturing facility. Sediment sampling in and around the stormwater discharge areas identified PCB sediment contamination in excess of 50 ppm in two distinct

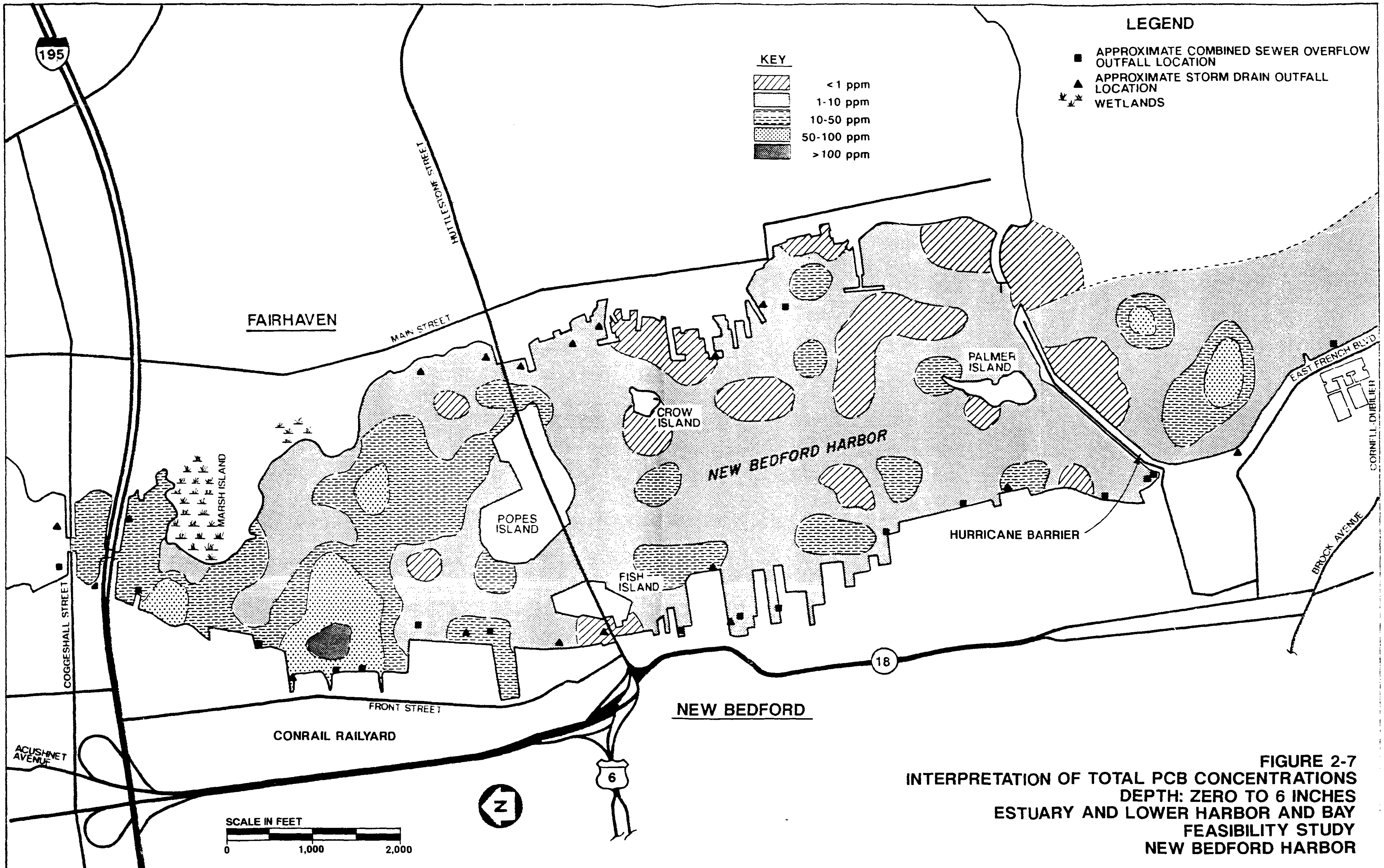


FIGURE 2-7
INTERPRETATION OF TOTAL PCB CONCENTRATIONS
DEPTH: ZERO TO 6 INCHES
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

locations. Sampling outside the Hurricane Barrier focused on the New Bedford shoreline. Few sediment samples were collected in the eastern part of the bay.

2.2.3.2 Metals

The interpretation of sediment metals contamination in the lower harbor/bay is illustrated in Figure 2-8. Figure 2-8 interprets the metals data in the top 6 inches of sediment. Insufficient data were available below the 6-inch interval for contouring. Total metals concentrations analyzed below this depth ranged from less than 10 ppm to greater than 2,400 ppm.

Metals contamination in the top 6 inches of the lower harbor/bay is highest in the area between the Route I-195 and Route 6 bridges. However, unlike PCB data, the estuary does not appear to be the main source of contamination. The most likely source of metals contamination in this area is the industrialized shoreline of New Bedford. Effluents from metal plating and manufacturing and textile dyeing operations were discharged throughout this area over an 80-year period and are suspected as the primary source of metals contamination (NUS, 1984a).

Metals contamination in the top 6 inches of sediment between the Route 6 Bridge and the Hurricane Barrier, and into the outer bay, is markedly decreased from the upper harbor area between the Route I-195 and Route 6 bridges. The highest concentrations are located in the vicinity of the Route 6 Bridge. Sediment metals concentrations decrease significantly with distance from this area to the outer bay.

With respect to remediation in the estuary and lower harbor/bay, most of the high metals concentrations are located in the top 1-foot layer of sediment, as are the higher PCB concentrations. Therefore, remediation of the PCBs would also remediate a large portion of the metals contamination. This is important from an engineering perspective because the removal/treatment alternatives selected for PCBs also will have to be effective for metals or recognize secondary waste management requirements for process residuals containing high metals concentrations.

2.2.4 Determination of Sediment Areas and Volumes for Potential Remediation

In practical terms, any remedial activities (i.e., capping or dredging) in the estuary and the lower harbor/bay would not be conducted using the contaminant isopleth maps developed in Subsection 2.2. To account for the operational limitations of dredging or capping activities, a grid-coordinate system would be used as a means of controlling and monitoring these remedial activities. A survey of the area to be remediated would be conducted to establish a grid-coordinate system for the site.

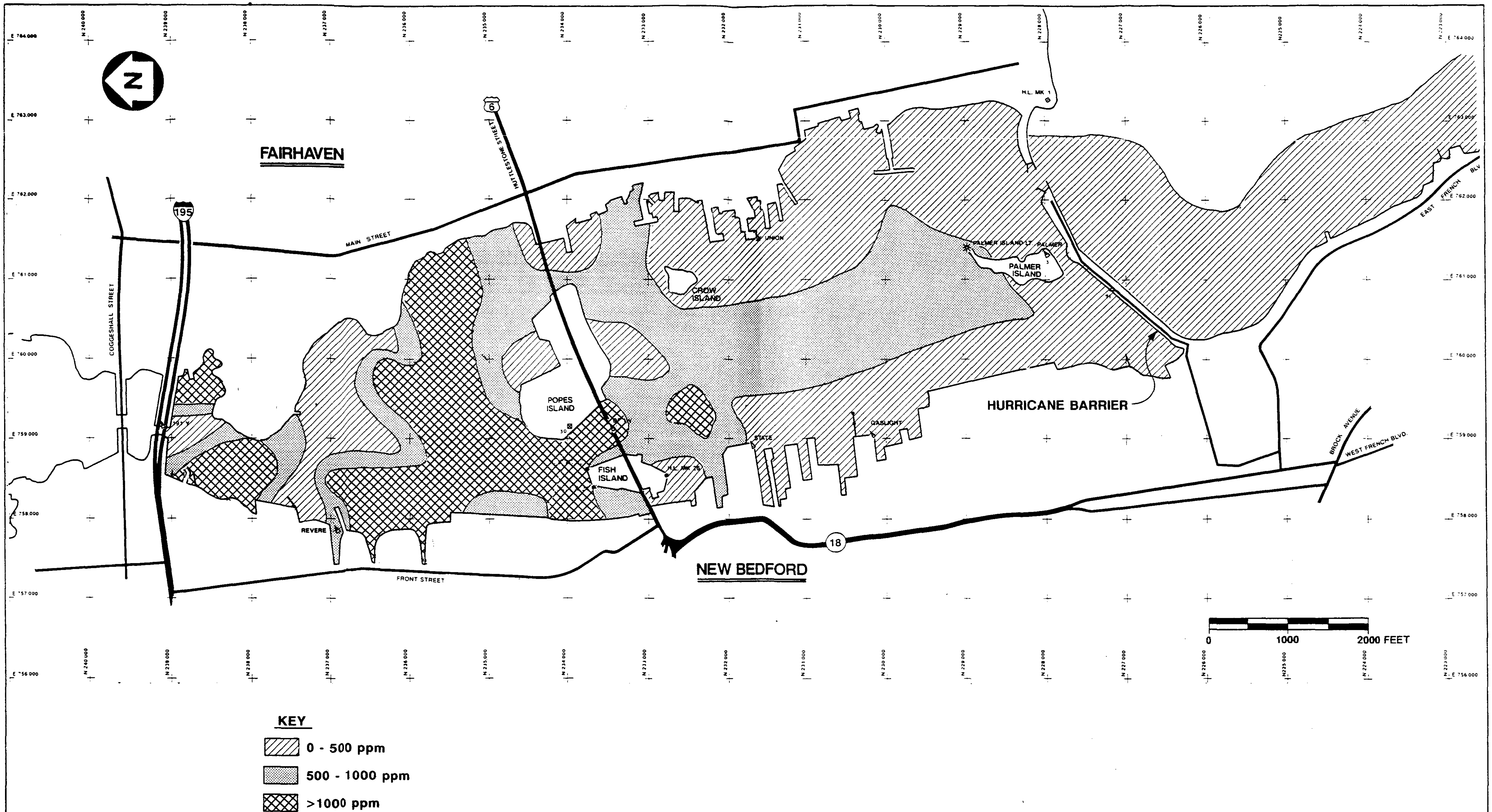


FIGURE 2-8
INTERPRETATION OF TOTAL METALS CONCENTRATIONS, ZERO TO 6 INCHES
(CADMIUM, CHROMIUM, COPPER, AND LEAD)
LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

Areas and volumes of contaminated sediment requiring remediation to achieve a desired TCL would be identified by individual grids. The grid locations would be used to guide remedial operations. Four potential TCLs were selected to calculate areas and volumes of contaminated sediment: greater than 1 ppm, greater than 10 ppm, greater than 50 ppm, and greater than 500 ppm. Areas and sediment volumes in the estuary and the lower harbor/bay requiring potential remediation to a specified TCL are discussed in the following subsections.

2.2.4.1 Upper Estuary

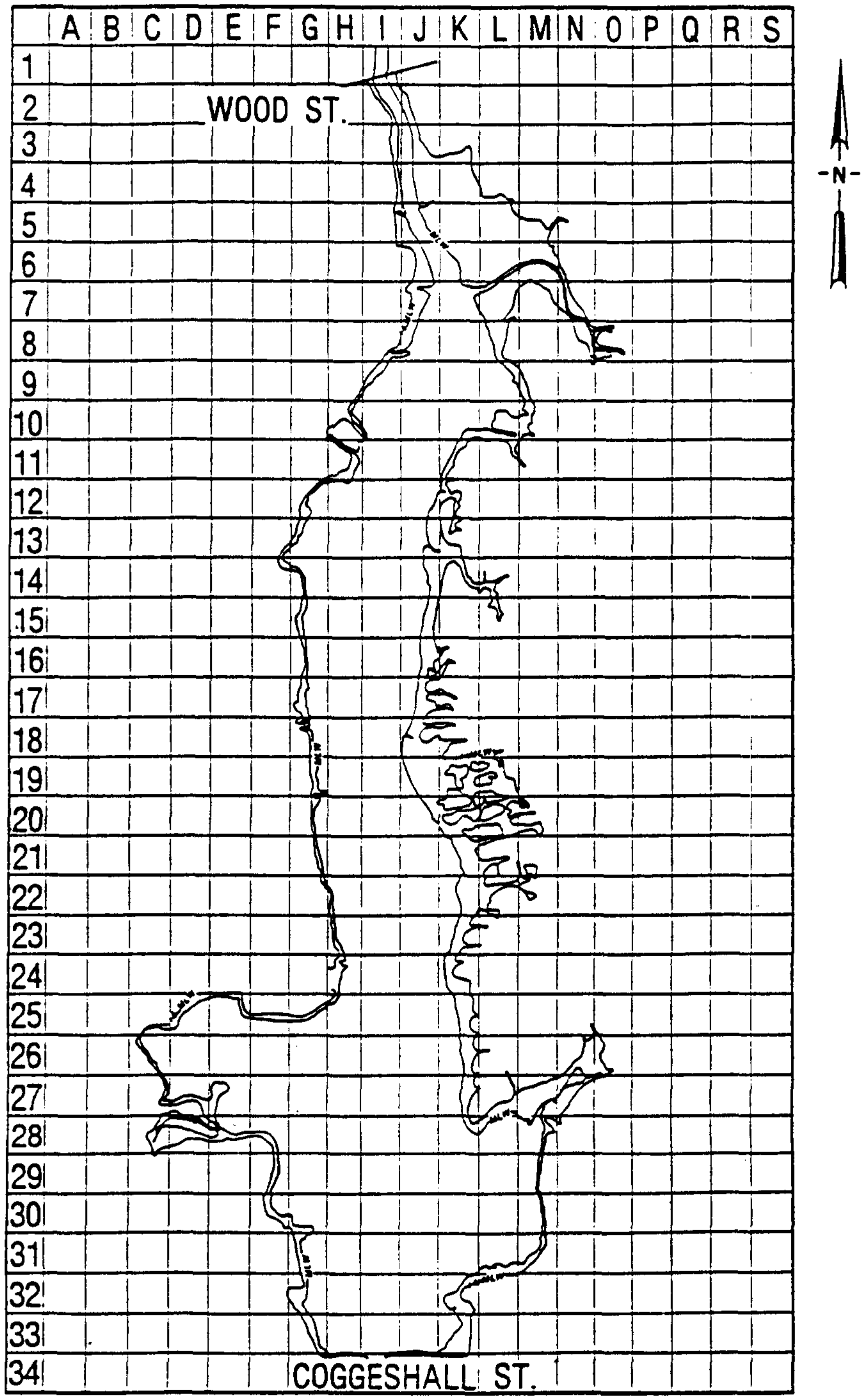
The Acushnet River Estuary in New Bedford Harbor has been defined by USACE as a 187-acre area lying within the 4-foot MLW level (USACE-NED, 1990). USACE used a 250-by-250-foot grid-coordinate system to identify sampling locations during its estuary sampling programs. The USACE sampling grid was overlain onto the contaminant isopleth maps developed in Subsection 2.2. The area of the estuary requiring remediation for a given TCL was determined by counting the number of grids within the contour interval for that given TCL.

Grid areas on the edges of the contour interval were estimated to within a quarter of a grid. Because each grid represents an area of 1.44 acres (i.e., 62,500 square feet), the total area was determined by multiplying the number of grids by 1.44. For example, 114 grids were found to lie within the 10-ppm contour interval defined on the isopleth maps. Consequently, approximately 164 acres would require remediation for a PCB TCL of 10 ppm. Figure 2-9 shows the grid-coordinate system for the estuary area.

For remedial alternatives requiring removal of the sediment, isopleth maps were used to identify the sediment depth required to reach the residual TCL. This number was multiplied by the area in each associated grid and expressed as cubic yards (cy). For example, the PCB isopleth maps for the estuary indicate that removal of the top 2 feet of sediment would be sufficient to achieve the 10-ppm TCL in all except two areas: one area along the western shoreline and another area just south of the former Hot Spot Area. Although additional sediment sampling would be required to better define the depth, it was assumed that the removal of the next foot of sediment in those two areas would remove contaminated sediment in excess of 10 ppm. Therefore, the volume of sediment requiring dredging to leave a residual of 10 ppm was calculated to be the following:

$$(114 \text{ grids} \times [62{,}500 \text{ ft}^2/\text{grid} \times 2\text{-ft depth/grid}])/27 \text{ ft}^3/\text{cy} = 528{,}000 \text{ cy}$$

The areas and sediment volumes in the upper estuary requiring remediation to achieve other TCLs are presented in Table 2-1.



SCALE IN FEET

0 500 1,000 2,000

SOURCE: USACE EFS REPORT II.

FIGURE 2-9
UPPER ESTUARY GRID SYSTEM
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

TABLE 2-1
AREAS AND VOLUMES FOR ASSOCIATED TARGET CLEAN-UP LEVELS IN SEDIMENT

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY

STUDY AREA	TARGET CLEAN-UP LEVEL (ppm)	VOLUME (cy)	AREA (acres)
Estuary	>1	572,000	178
	>10	528,000	164
	>50	378,000	118
	>500	149,000	46
Lower Harbor/ Bay	>1	1,259,000	780
	>10	398,000	246
	>50	76,000	47
	>500	7,000	4.3

NOTES:

ppm = parts per million

cy = cubic yards

If the contaminated wetland areas along the eastern shoreline of the estuary study area were to be remediated as a component of the removal alternatives, an additional 43 acres would need to be addressed. Dredging at a 2-foot depth would be required to remediate the wetlands to the 10-ppm TCL. This would add approximately 139,000 cy to the total amount of sediment to be disposed of or treated.

2.2.4.2 Lower Harbor/Bay

The remedial areas and sediment volumes in the lower harbor/bay were estimated using the same method applied to the estuary. The USACE grid-coordinate system developed for the estuary was extended into the lower harbor/bay. However, due to the areal extent of the harbor, each grid was enlarged to 500 by 500 feet. Therefore, each grid represents an area of 5.79 acres (i.e., 250,000 square feet).

Available sampling data for the lower harbor/bay indicate that most of the PCB contamination in the sediment resides in the top 6 inches. Therefore, removal of the top foot of sediment (the minimum practical depth that could be removed during dredging operations) would achieve the 10-ppm TCL. Applying the grid to the PCB isopleth maps for the lower harbor/bay and assuming a TCL of 10 ppm, approximately 246 acres (or approximately 398,000 cy) would require remediation.

The areas and sediment volumes in the lower harbor/bay requiring remediation to achieve other TCLs are presented in Table 2-1.

2.3 CONTAMINANT TRANSPORT AND FATE

[NOTE: Section 2.3 may be extensively revised pending completion of REM III team review of Battelle's Draft Final Modeling Report.]

2.3.1 Transport of Polychlorinated Biphenyls

The horizontal and vertical transport of PCBs within New Bedford Harbor and upper Buzzards Bay is mediated by various physical, chemical, and biological parameters or processes that define this system, including tide, current, and wind; sorption/desorption between sediment and water; sediment deposition/resuspension; volatilization; and bioturbation.

As part of the New Bedford Harbor FS program, a three-dimensional hydrodynamic and sediment-contaminant transport computer model was developed and applied to New Bedford Harbor. The objective of this modeling program was to provide a physics-based analysis of contaminant transport and fate. In addition, the model served as a tool in the comparative evaluation of no-action and proposed remedial action alternatives over a 10-year future period. Of primary interest were the flux of PCBs between the bed and the water column, the effects of "clean sediment" deposition to the bed as a dilution factor, the volatilization of PCBs to the atmosphere, and the net tidal and non-tidal transport of PCBs throughout the system.

Detailed descriptions of the model, the model formulation used for New Bedford Harbor, and the hydrodynamics and sediment-contaminant calibrations are presented in a comprehensive report documenting the modeling program (Battelle, 1990). The components of the modeling program relative to the results discussed in this FS are described in the following subsections.

2.3.1.1 The TEMPEST/FLESCOT Model

The numerical model used in this study was the three-dimensional hydrodynamics code TEMPEST (Trent and Eyler, 1989), coupled with a sediment-contaminant transport submodel FLESCOT (Onishi and Trent, 1982). The marine version of TEMPEST solves the conservation equations of fluid mass, momentum, thermal energy, and constituent transport (e.g., salt) using standard finite-difference techniques. The sediment-contaminant transport submodel, FLESCOT, adds the following transport equations and associated source/sink terms to the TEMPEST code: suspended sediment, dissolved contaminant, and sediment-sorbed contaminant.

Sediments and sediment-sorbed contaminants are eroded from and deposited to a layered seabed. The model considers three sediment grain-size classes: sand, silt, and clay. Contaminant mass transfer between the sediment and the water column occurs through the erosion and deposition of sediment-sorbed contaminant, and direct desorption or adsorption through a sediment-water column partition coefficient and a rate constant. The FLESCOT model does not account for diffusion of contaminants within the interstitial pore waters of the bed sediments. The partitioning of contaminant in the water column between dissolved and sorbed form is modeled using an equilibrium partition coefficient and a rate constant. Nonconservative contaminants and the volatilization of dissolved contaminants are modeled as first-order rate processes.

2.3.1.2 TEMPEST/FLESCOT Formulation for New Bedford Harbor

The TEMPEST/FLESCOT model was applied to New Bedford Harbor and portions of adjoining Buzzards Bay. This area was divided into a 46-by-46-by-8 nonuniform Cartesian grid. A plan view of the computational grid and key geographical points is shown in Figure 2-10. The bathymetry was defined using information obtained from the National Oceanic and Atmospheric Administration Buzzards Bay Chart (#13230) and recent surveys

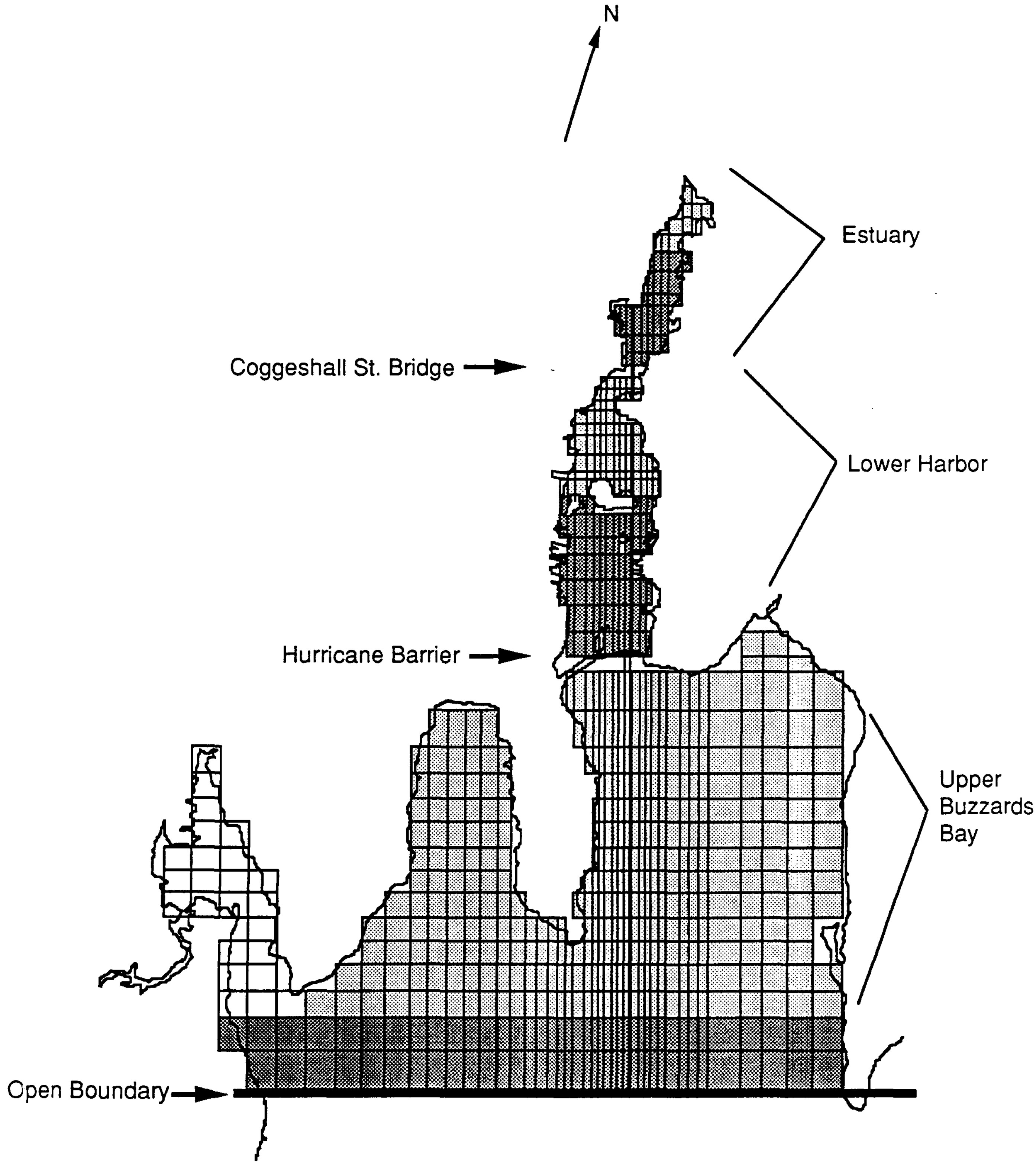


FIGURE 2-10
COMPUTATIONAL GRID FOR TEMPEST/FLESCOT MODEL
ESTUARY AND LOWER HARBOR AND
BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

conducted by USACE. Depths in the modeled area range from 0.3 to 10 meters below the MLW level.

Freshwater inflow from the Acushnet River was ignored because of its low average annual flow rate; that is, approximately 0.85 cubic meters per second (Teeter, 1988).

2.3.1.3 Calibration of the TEMPEST/FLESCOT Model

Hydrodynamics were calibrated using two 24-hour periods simulating site conditions: an M2 tide (12.42-hour period) and northerly 2- to 10-m/sec winds. Wind speed and direction were applied uniformly over the computational domain. The computed results of these simulations were compared with measured field data collected during the calibration periods by USACE (New England Division) and Woods Hole Oceanographic Institution (WHOI). USACE measured wind speed and direction at the Hurricane Barrier. WHOI measured current velocities and direction, and water surface elevations using current meters and tide gauges deployed at various locations throughout New Bedford Harbor. Details on these field data collection activities are presented elsewhere (Battelle, 1990). The effects of episodic storm events, with a monthly recurrence interval, were incorporated using a 24-hour simulation forced by an M2 tide and southerly 1- to 15-m/sec winds.

Sediment-PCB calibration simulations covered a 92-day period in the following five sequential stages: (1) 30-day general case, (2) 1-day storm case, (3) 30-day general case, (4) 1-day storm case, and (5) 30-day general case. The final water column and sediment bed conditions for one stage served as the initial conditions for the next stage.

Initial conditions for bed sediment grain-size distribution and total PCBs sorbed to bed sediments were assigned based on field survey data. To obtain a sufficient level of detail to assign seabed conditions throughout the computational domain of the model, several sets of data collected at different times had to be used. Details on how these data sets were selected and used are discussed by Battelle (Battelle, 1990).

The FLESCOT model formulation for New Bedford Harbor assumes a sediment bed depth of only 4 centimeters (cm) as the active zone over which mass transfer of PCBs from the sediment to the overlying water column occurs. The initial sediment PCB concentrations assigned in the model reside in this 4-cm surficial sediment layer. In reality, sediment PCB concentrations are significantly higher at depths greater than 4-cm throughout most of the area modeled. Numerous mechanisms, including sediment scouring and erosion, diffusion, or bioturbation, could make the highly contaminated sediments below the 4-cm surficial layer available for transport into the overlying water column. Therefore, numerical results of the modeling program should not be viewed as absolute but rather as a reflection of relative changes occurring in the New Bedford Harbor system.

Sediment and PCB transport was calibrated by comparing computed values to water column data collected by Battelle in 1985 at various sampling station locations throughout New Bedford Harbor and upper Buzzards Bay (Battelle, 1990). Simulation results using the final set of parameter values were compared to the Battelle field data. Agreement between the calculations and measurements was fair; the mean computed value was within the range of the observed data at most stations.

The net computed flux of suspended sediments and PCBs (in kilograms per tidal cycle) through the Coggeshall Street Bridge constriction was compared with those measured by Teeter (Teeter, 1988). As shown in Table 2-2, the model produces the correct net transport direction, although the computed results are lower than the measurements. One reason for the lack of agreement is that the field measurements were made under tide and wind conditions different than those used in the model simulations.

2.3.1.4 Transport Processes Simulated by the TEMPEST/FLESCOT Model

The net flux of suspended sediments and total PCBs was calculated at several planes in the computational grid. The flux calculation planes, shown in Figure 2-11, were chosen to correspond to the principal constrictions in the system (e.g., the Coggeshall Street Bridge and the Hurricane Barrier) and the open boundary of the model. In addition to the flux information, the computed sediment and PCB values in each water column and seabed grid cell were averaged over six zones. Zones 1 and 2 encompass the upper estuary, Zones 3 and 4 the lower harbor, and Zones 5 and 6 the outer harbor or upper Buzzards Bay. Locations of the averaging zones are shown in Figure 2-11. Using this information, it was possible to perform mass balances over key geographic regions in the study area.

The computed net flux of suspended sediments and total PCBs is summarized in Table 2-3. The results show that the upper estuary and the inner harbor are depositional areas for sediment. In the area south of the Hurricane Barrier, sediments are being transported out of the system toward Buzzards Bay. This is caused, in part, by the fact that the modeled sediment transport for the large area south of the Hurricane Barrier is still in the process of coming into equilibrium with the specified initial bed conditions and the open boundary condition.

TABLE 2-2
NET FLUX OF SUSPENDED SEDIMENT AND TOTAL PCBS IN KILOGRAMS PER TIDAL CYCLE

ESTUARY AND LOWER/HARBOR BAY FEASIBILITY STUDY

	Computed	Teeter (1988)
Total Suspended Sediment Flux	446	2,202
Total PCB Flux	-0.22	-1.55

NOTE: Negative flux is out of the system toward Buzzards Bay.

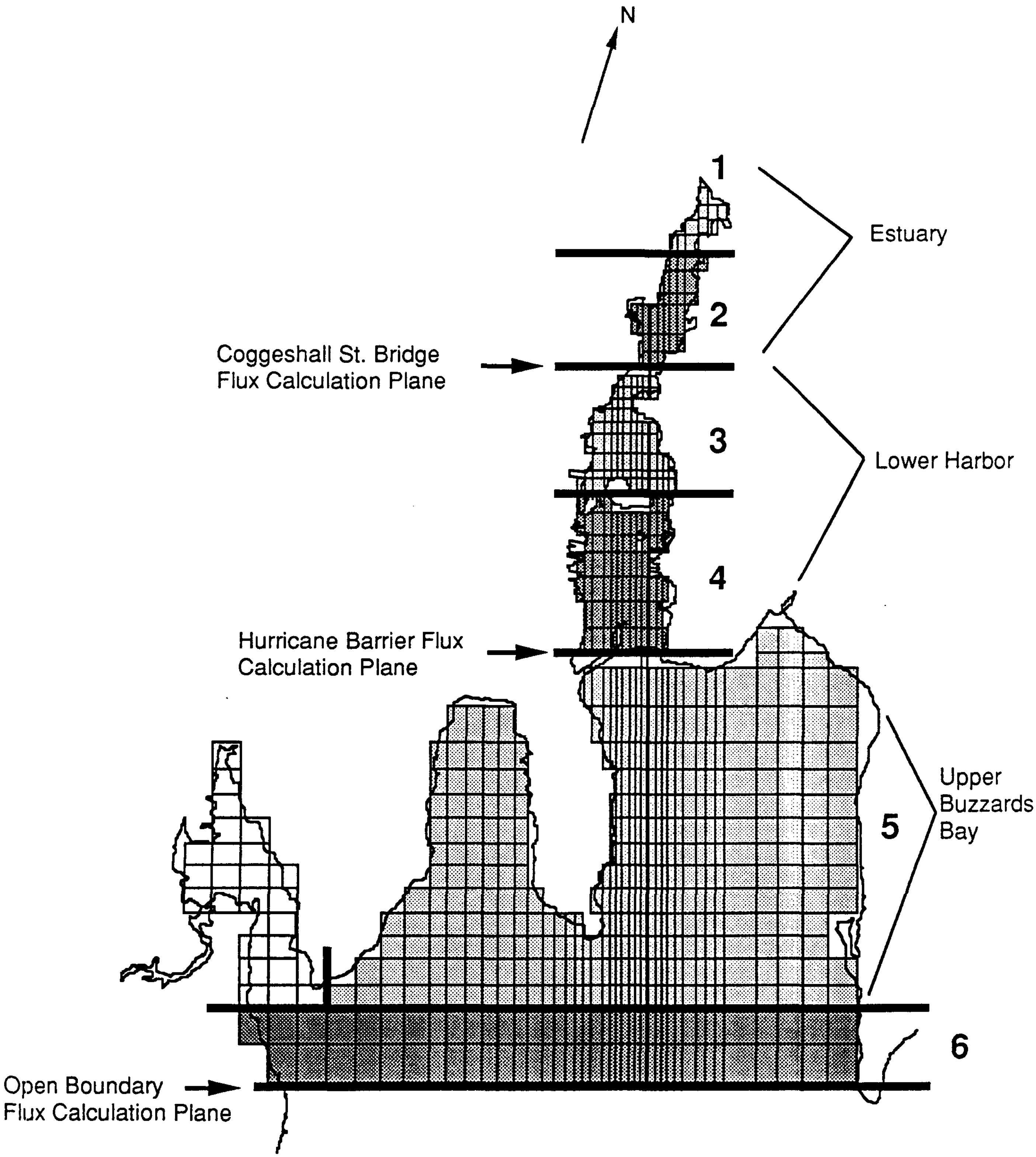


FIGURE 2-11
BOX AVERAGE ZONES AND FLUX CALCULATION PLANES
ESTUARY AND LOWER HARBOR AND
BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

	Coggeshall St. Bridge	Hurricane Barrier	Open Boundary
Total Suspended Sediment Flux	446	1,546	-24,641
Total PCB Flux	-0.22	-0.15	-1.32

Table 2-3 : Computed Net Flux of Suspended Sediment and Total PCBs in kg/tidal cycle. Negative Flux is Out of the System towards Buzzards Bay

Zones 1 & 2 Upper Estuary				
Sediments	**Initial Mass (kg)**	**Net Mass Flux (kg)**	**Final Mass (kg)**	**Mass Change (kg)**
Water Column Mass	2,945	+82,000	4,442	+1,497
Seabed Mass	49,720,000		49,800,000	+80,000
PCBs				
Water Column Mass	0.39	-40.0	0.12	-0.27
Seabed Mass	19,714		19,431	-283
Zones 3 & 4 Inner Harbor				
Sediments	**Initial Mass (kg)**	**Net Mass Flux (kg)**	**Final Mass (kg)**	**Mass Change (kg)**
Water Column Mass	32,398	+202,282	80,460	48,062
Seabed Mass	165,670,000		165,860,000	190,000
PCBs				
Water Column Mass	1.58	+13.42	2.62	+1.04
Seabed Mass	1,778		1,733	-45
Zones 5 & 6 Outer Harbor				
Sediments	**Initial Mass (kg)**	**Net Mass Flux (kg)**	**Final Mass (kg)**	**Mass Change (kg)**
Water Column Mass	333,300	-4,815,596	937,100	+603,800
Seabed Mass	1,402,300,000		1,397,700,000	-4,600,000
PCBs				
Water Column Mass	15.53	-215.5	5.15	-10.38
Seabed Mass	4,492		4,206	-286

Table 2-4 : Computed Mass Balance for No Action

The computed net flux of PCBs through each plane is toward Buzzards Bay. PCBs are being transported out of the upper estuary through and into the inner harbor at a rate of 155 kilograms per year (kg/yr). Similarly, PCBs are transported through the Hurricane Barrier into Buzzards Bay at a rate of 105 kg/yr.

Table 2-4 presents a mass balance analysis of the computed results. As indicated by the net flux computations, the upper estuary is a depositional area for sediments. During the course of the 92-day calibration simulation, the upper estuary received an additional 82,000 kg of sediment. Although sediments with a lower sorbed PCB concentration were being transported and deposited into the upper estuary, the mass of PCBs within the sediments decreased only slightly. This indicated that PCB mass transfer from the bed to the water column, which is modeled as a desorption process, is more significant than mass transfer of PCBs absorbed to particles through erosion or deposition. The average concentration of PCBs in bed sediments was initially approximately 397 milligrams per kilogram (mg/kg). Had all the sediment that was added to the seabed been deposited with a zero PCB concentration and no PCB mass was lost due to desorption, the resulting average concentration would be 396 mg/kg. The actual final concentration was 390 mg/kg. Therefore, even under ideal conditions, deposition of cleaner sediments is not a significant transport process in the upper estuary.

Volatilization appears to be the most significant process occurring in the simulation of the upper estuary. The PCB volatilization rate used in the model was set to the mean of several literature values for similar water bodies (Bopp, 1983). A spatially uniform volatilization coefficient of 1.3×10^{-5} m/sec was used. Approximately 243 kg of PCBs, or 86 percent of the original 283 kg which migrates from the sediment into the overlying water column, is removed from the system in the 92-day simulation through volatilization.

The importance of volatilization is further evidenced by the mass balance calculations for the inner harbor area. This area receives a net influx of PCBs from the upper estuary, and a lesser amount of PCBs is transported out of the inner harbor through the Hurricane Barrier. However, the inner harbor still experienced a net PCB loss of 45 kg. Although sediment deposition is occurring in the inner harbor, as was the case in the upper estuary, this process is not a significant contribution to the transport of PCBs. The average concentration of PCBs within the bed sediments changes very little; the initial and final concentrations are 10.7 and 10.4 mg/kg, respectively.

In deeper waters outside the Hurricane Barrier in the outer harbor, volatilization accounts for only 81 kg of the PCB mass transport. PCB transport by sediment erosion only accounts for approximately 14 kg of the 286 kg lost from the bed. These estimates are based on the mass of sediment eroded from the bed and the average PCB concentration of 3.0 mg/kg. Again, mass transfer of PCBs from the seabed to the water column and subsequent transport in the water is the most significant process.

In summary, results of the TEMPEST/FLESCOT model simulation show that the transfer of PCBs from the bed to the water column through direct desorption and the subsequent volatilization of PCBs from the water column are the most important transfer processes. Volatilization in the shallow areas of the upper estuary is significant.

2.3.1.5 Other Transport Studies

Numerous studies have shown that the upper estuary and the inner harbor are depositional areas for sediment (Summerhayes et al., 1977; and Teeter, 1988). USACE field measurements of total suspended material (TSM) collected at the Coggeshall Street Bridge showed a net flux of TSM always landward or upstream. About one third of the sediment that enters the upper estuary on the flood tide settled out during that tidal cycle. Average net flux of TSM into the upper estuary was about 2,200 kg per tidal cycle (Teeter, 1988). This number is nearly five times higher than the 446-kg flux computed by the TEMPEST/FLESCOT simulations. One reason for the lack of agreement is that the field measurements were made under tide and wind conditions different than those used in the model simulation.

The natural deposition of "clean" sediment would not be expected to provide effective cover or to dilute the contaminated surface sediment. Teeter estimated that the net flux of 2,200 kg of TSM into the upper estuary would result in a sedimentation rate of 3 millimeters per year when spread over the entire surface area (approximately 800,000 square meters at mean tide) of the upper harbor at a bulk wet density of 1.5 grams per cubic cm (Teeter, 1988). However, actual sedimentation rates will vary widely over the upper estuary, depending on current, wave, and depth regimes (Teeter, 1988). Brown and Wagner examined sediment core samples from the upper estuary and found no consistent pattern of sedimentation between the 5- to 7.5-cm and the 15- to 17.5-cm depths (Brown and Wagner, 1986). Other reports identified PCB concentrations in the surface layers as equal to subsurface concentrations, despite cessation of PCB release, continued sedimentation, and PCB losses to the water column (Brown and Wagner, 1986).

Measured concentrations of PCBs in the water in New Bedford Harbor provide evidence that the sediment is a substantial source of PCBs to the overlying water column. Average PCB concentrations in the water column range from 826 to 5,889 nanograms per liter (ng/L) in the estuary (EPA, 1983b; Battelle, 1985; and Applied Science Associates, Inc., 1989); 174 to 322 ng/L in the lower harbor (Battelle, 1985); and 31 to 95 ng/L in the bay (Battelle, 1985). These measurements show a PCB concentration gradient that decreases with increasing distance from the estuary.

The continuous release of PCBs in the presence of ongoing general deposition suggests that PCBs are able to migrate vertically to the surface of the sediment bed, through the sediment-water interface, and into the water column. Numerous transport mechanisms have been investigated or proposed, including adsorption/desorption (Brownawell, 1986), bioturbation (Thibodeaux, 1989), and particle exchange (Teeter, 1988). Brownawell investigated the sorption of PCBs with colloidal organic material in seawater and the influence of this process on the distribution of PCBs in coastal sediments. The interstitial waters from the organic-rich sediment from New Bedford Harbor contain high concentrations of colloidal organic matter. Elevated PCB concentrations found in the interstitial waters (compared to water column concentrations) provided evidence that the PCBs were in a dynamic equilibrium with the colloidal and sediment organic matter. Brownawell concluded that the mobility of this colloidal-sorbed PCB phase could provide an important source of flux of PCBs across the sediment-water interface to the water column (Brownawell, 1986). Thibodeaux suggested that the dominant PCB transport mechanism from the sediment to the water column is via bioturbation (Thibodeaux, 1989). This process refers to the activities of animals (e.g., burrowing, ingestion/defecation, tube-building, and biodeposition) residing primarily in the top 3 to 10 cm of sediment, which cause a net physical vertical and horizontal movement of sediment particles and pore water.

Teeter evaluated particle exchange as a mechanism of transporting PCBs from contaminated bed sediment (Teeter, 1988). This process in known to operate in fine, cohesive sediment and suspensions similar to those found in the upper estuary. Teeter's analysis proposes that PCBs attached to the sediment particles at the surface of the bed in New Bedford Harbor could be exchanged into the overlying sediment suspended in the water column, along with sediment particles by a physical particle exchange mechanism. The net vertical transport of contaminant resulting from particle exchange would be in the direction of reduced concentrations. The flux of particle-associated contaminants depends on the mass rate of particle exchange between bed sediment and suspension, and on the difference in contaminant concentration between bed and suspended particles.

The flux of PCBs from the sediment in the upper estuary to the water column was computed to be 1,123 kg/yr during the

TEMPEST/FLESCOT model simulation (Battelle, 1990). This estimate compares favorably with other studies. Based on the results of three chemodynamic models correlating PCB water column concentrations and sediment flux, Thibodeaux estimated the total flux of PCBs leaving estuary sediment to range from 500 to 6,000 kg/yr (Thibodeaux, 1989). Applied Science Associates, Inc. (ASA) estimated a PCB flux of 1,700 kg/yr from the upper estuary sediments (ASA, 1989).

The TEMPEST/FLESCOT model computed a net seaward flux of 155 and 105 kg/yr of PCBs at the Coggeshall Street Bridge and the Hurricane Barrier, respectively. Measured concentrations of PCBs in the water of the upper estuary correlated with tidal cycles confirm the transport of PCBs out of the estuary (Teeter, 1988). Total PCB concentrations in the water column ranged from 1,300 to 5,800 ng/L on the ebb tide, and 500 to 3,000 ng/L on the flood tide. Based on these measurements, Teeter calculated a seaward PCB flux ranging from 49.3 to 1,663.8 kg/yr, with a mean of 1,092 kg/yr (Teeter, 1988). Similar studies have estimated seaward PCB flux in this range (EPA, 1983b; and ASA, 1989).

Tidal pumping was determined to be the dominant transport mechanism for landward flux of suspended sediment and seaward flux of PCBs. Teeter evaluated three important estuarine transport processes for suspended material: transport by net flow, vertical circulation, and tidal pumping (Teeter, 1989). He concluded that tidal pumping was the most dominant transport process. ASA conducted a continuous dye-release study simulating the release of PCBs in the water column of the estuary (ASA, 1987). This study confirmed tidal flushing through the Hurricane Barrier. The flushing time for the estuary was estimated at 2.4 days (ASA, 1987).

Results of the TEMPEST/FLESCOT model simulation indicated that volatilization of PCBs from the water column was a significant transport mechanism. This finding is supported by other studies. Thibodeaux calculated that at least 41 percent of the PCBs entering the water column from the estuary sediment evaporates into the air; the remaining 59 percent is transported seaward through the Coggeshall Street Bridge (Thibodeaux, 1989). Thibodeaux's calculations were based on a volatilization coefficient of 1.68 meters per day (m/day) (1.95×10^{-5} m/sec). ASA used a volatilization coefficient of 2.37 m/day obtained from Lyman, and calculated a PCB evaporative loss of 50 percent (ASA, 1989; and Lyman et al., 1982).

2.3.1.6 Long-term Transport

An estimation of the long-term transport and fate of PCBs in the New Bedford Harbor system in the absence of remedial action (i.e., no action) was simulated for a 10-year future period using the TEMPEST/FLESCOT model. This simulation case was essentially a continuation of the 92-day model calibration described previously. Year Zero of the no-action case corresponded to the final state of the 92-day model calibration sequence.

Each 92-day sediment-contaminant calibration simulation consumed about 5 hours of CPU time on a Cray XMP supercomputer. Because the computer costs to generate a continuous 10-year simulation are prohibitive, the simulation was done using the following method. For each five-stage, 92-day series, the rate of mass change in each bed cell was computed. Using this rate of change, the mass in each bed cell was linearly extrapolated forward using a two-year time step. The extrapolated bed conditions defined a new initial bed condition for the next 92-day simulation. The steps were repeated until the tenth year was reached. The model parameters and open boundary conditions were held constant in each step. Using this scheme, simulations for Years Zero, 2, 4, 6, 8, and 10 were computed.

To facilitate interpretation of the simulation results, the computed values in each grid cell were averaged for each of the six zones identified in Figure 2-11.

Details on the results of the 10-year no-action simulation are presented elsewhere (Battelle, 1990). In general, the results show steady declines in sediment bed and water column PCB concentrations throughout the New Bedford Harbor system. By the end of the 10-year simulation, PCB mass in the sediment has been reduced by approximately 27 percent in the upper estuary (Zones 1 and 2); 21 percent in the lower harbor (Zones 3 and 4); and 60 percent in upper Buzzards Bay (outer harbor Zones 5 and 6). Average water column PCB concentration decreased by approximately a factor of 2 in the upper estuary, 1.6 in the lower harbor, and 2.3 in the outer harbor.

The computed net flux of total suspended sediment and total PCBs for Year Zero and Year 10 is summarized in Table 2-5. Results for the interim two-year periods are presented elsewhere (Battelle, 1990). Suspended sediments are transported into the lower harbor and upper estuary throughout the long-term simulation.

Sediment deposition in the upper estuary and lower harbor is relatively steady (approximately 1 and 1.5 percent per two-year period, respectively) over the 10-year simulation period. Initially, sediments are transported out of the system through the open boundary; however, by Year 4, the flux direction has reversed because the model has reached an equilibrium condition between sediments eroded and/or deposited from the seabed and those transported through the open boundary.

	YEAR 0			YEAR 10		
	Coggeshall St. Bridge	Hurricane Barrier	Open Boundary	Coggeshall St. Bridge	Hurricane Barrier	Open Boundary
Total Suspended Sediment Flux	446	1,546	-24,641	282	2,120	24,968
Total PCB Flux	-0.22	-0.15	-1.32	-0.20	-0.11	-0.30

Table 2-5 : Computed net flux of suspended sediment and total PCBs in kg/tidal cycle for Year 0 and Year 10. Negative flux is out of the system toward Buzzards Bay

Mass Balance

Zones 1 & 2 Upper Estuary			
Sediments	Year 0 Mass (kg)	Year 10 Mass (kg)	Mass Change (kg)
Water Column Mass	4,442	3,101	-1,341
Seabed Mass	49,800,000	52,330,000	2,530,000
PCBs			
Water Column Mass	2.88	1.59	-1.29
Seabed Mass	19,431	14,267	-5,164
Zones 3 & 4 Inner Harbor			
Sediments	Year 0 Mass (kg)	Year 10 Mass (kg)	Mass Change (kg)
Water Column Mass	80,460	59,450	-21,010
Seabed Mass	165,860,000	179,380,000	13,520,000
PCBs			
Water Column Mass	2.62	1.61	-1.01
Seabed Mass	1,733	1,374	-359
Zones 5 & 6 Outer Harbor			
Sediments	Year 0 Mass (kg)	Year 10 Mass (kg)	Mass Change (kg)
Water Column Mass	937,100	833,100	-104,000
Seabed Mass	1,397,700,000	1,493,300,000	95,600,000
PCBs			
Water Column Mass	5.15	2.01	-3.14
Seabed Mass	4,206	1,666	-2,540

Table 2-6: Computed Mass Balance for 10 Year No Action Simulation

The flux of PCBs is out of the system toward Buzzards Bay throughout the 10-year simulation. Flux of PCBs through the Coggeshall Street Bridge and the Hurricane Barrier remains approximately the same, while the flux through the open boundary decreased in response to the decrease in concentration of PCBs in the bed sediments outside the Hurricane Barrier. This suggests that the initial concentration of PCBs in the sediment outside the Hurricane Barrier may have been biased toward higher levels because the field data were collected mainly in areas of known contamination.

Table 2-6 shows the computed mass balance for sediment and water column PCBs for the important geographic areas. Over the 10-year simulation, the average concentration of PCBs in the bed sediments of the upper estuary decreased from 390 to 273 ppm. Average water column PCB concentrations in the upper estuary decreased from 2,010 parts per billion (ppb) in Year Zero to 1,107 ppb in Year 10. Total PCB mass lost over the 10-year period is 5,164 kg. Based on a net PCB flux rate at the Coggeshall Street Bridge of 0.20 kg per tidal cycle (i.e., 705 tidal cycles per year), and assuming it to remain constant over the 10-year period, approximately 1,411 kg of PCB mass is transported out of the upper estuary in the water column. This leaves 3,753 kg of PCBs that must be lost to the atmosphere, or approximately 0.53 kg per tidal cycle. The lower harbor/bay shows similar trends of sediment deposition and decreasing PCB mass.

2.3.1.7 Summary of the TEMPEST/FLESCOT Model Results

Overall results of the TEMPEST/FLESCOT model simulation and other transport studies confirm that significant transport of sediment and PCBs is occurring in the New Bedford Harbor system. Although there is a net landward flux of suspended sediments, deposition of "clean" sediment in the lower harbor and estuary would not be expected to provide a sufficient cover to cap or isolate PCBs from the water column, nor would sediment deposition sufficiently dilute the contaminated sediment.

PCBs in the sediment are continuously migrating into the overlying water column. Measurements of sediment and water column PCBs indicate a large concentration gradient from the estuary to the lower harbor, with the highest concentrations in the estuary. Tidal pumping is the dominant transport mechanism for a net seaward flux of PCBs from the estuary into the lower harbor and through the Hurricane Barrier into Buzzards Bay. However, volatilization of PCBs from the water is also a major transport mechanism, accounting for perhaps as much as 50 percent of the loss of PCBs from the water column.

Long-term simulations of PCB transport indicate that a 20 to 30 percent reduction in sediment PCB mass would occur in the estuary and lower harbor areas, while a 60 percent reduction in PCB mass would be achieved in the outer harbor area over a 10-year period. However, average bed sediment and water column concentrations in the upper estuary at the end of the 10-year period would still remain relatively high at 273 ppm and 1,107 ppb, respectively.

Results of the TEMPEST/FLESCOT model simulations are based on initial conditions residing in the 4-cm surficial sediment layer. The sediment PCB concentrations assigned to this surficial layer do not represent the actual PCB concentrations which, in many areas of the estuary and lower harbor/bay, are much higher. Therefore, the TEMPEST/FLESCOT simulations provide a projection of relative rather than absolute trends.

2.3.2 Fate of Polychlorinated Biphenyls

Hydrolysis, photo-oxidation, and biological uptake are all processes affecting the ultimate fate of PCBs. Of these, biological uptake is the greatest concern because of environmental impacts, public health impacts associated with ingestion of the contaminated biota, and economic impacts on the local fishing industry.

Sustained elevated concentrations of PCBs in lobster and several other species have been documented in fishing closure Area 3 (see Figure 1-1). Monitoring conducted from 1977 to 1987 indicates mean PCB concentrations in lobsters have remained relatively constant, exceeding the 2-ppm FDA tolerance level. The mean PCB concentration was 3.9 ppm in 1977 (Kolek and Ceurvels, 1981); 4.2 ppm in 1985 (Massachusetts Division of Marine Fisheries, unpublished data); and 5 ppm in lobsters collected during 1987 (Pruell et al., 1988). PCB concentrations exceeding the 2-ppm tolerance level were also observed in winter flounder (Pruell et al., 1988). PCB levels in lobsters appear to have remained relatively constant over the past decade.

The concentration of a toxic substance in an aquatic animal is the result of several uptake and loss processes, including transfer across the gills, surface sorption, ingestion of contaminated food, desorption, metabolism, excretion, and growth. These processes are controlled by the bioenergetics of the animal, and the chemical and physical characteristics of the toxic substance (Battelle, 1990).

As part of the New Bedford Harbor FS program, a food chain computer model was developed and applied to New Bedford Harbor. The objective of this modeling program was to determine the concentrations of PCBs and metals in aquatic biota as a result of exposure to contaminated sediment and water. Contaminant concentrations in animals were computed with respect to time, location, and life-stage.

Detailed descriptions of the model, model formulation used for New Bedford Harbor, and model calibration are presented in a comprehensive report documenting the modeling program (Battelle, 1990). An overview of the food chain model as it relates to an understanding of the results discussed in this FS is presented in the following subsections.

2.3.2.1 The WASTOX Model

The numerical model used in this study was the FORTRAN code WASTOX (Connolly and Thomann, 1985). This model determines concentrations in aquatic animals by solving a differential equation describing the change in concentration in an animal by uptake of a chemical from water passing over its gills, contaminated food in its gut, and losing chemicals through excretion to the water. This differential equation must be solved simultaneously for each animal being modeled. A general mass balance for whole-body burden is derived by combining uptake and loss rates of the chemical contaminant. Uptake of the chemical due to ingestion of contaminated food considers the chemical concentration in the food, rate of food consumption, and the degree to which the ingested chemical in the food is actually assimilated into the tissues. Uptake of the chemical from water is determined by the rate of transfer of the chemical across the gills. The rate of loss of the chemical from the animal is the sum of the excretion and detoxification or degradation rates of the chemical. Specific bioenergetic- and chemical-related parameters are required as input for each species in the model. Bioenergetic-related parameters include growth rate, respiration rate, assimilation efficiency, and predator/prey relationships. Chemical-related parameters include assimilation efficiency of the chemical in the food, molecular diffusivity of the chemical, and the bioconcentration factor (BCF) or whole-body excretion rate. The variation of these parameters with age and the feeding habits of each species modeled must also be known.

2.3.2.2 WASTOX Formulation for New Bedford Harbor

The WASTOX model was applied to New Bedford Harbor and portions of adjoining Buzzards Bay. This area was divided into four compartments designated Areas 1 through 4. Figure 2-12 shows the segmentation of the study area. Two food chains were incorporated into the WASTOX model for New Bedford Harbor: the lobster (<u>Homarius americanus</u>) and the winter flounder (<u>Pseudopleuronectes americanus</u>). Both species are indigenous to the area. The lobster is the top predator in a three-level food chain represented by crabs, mussels, polychaetes, phytoplankton,

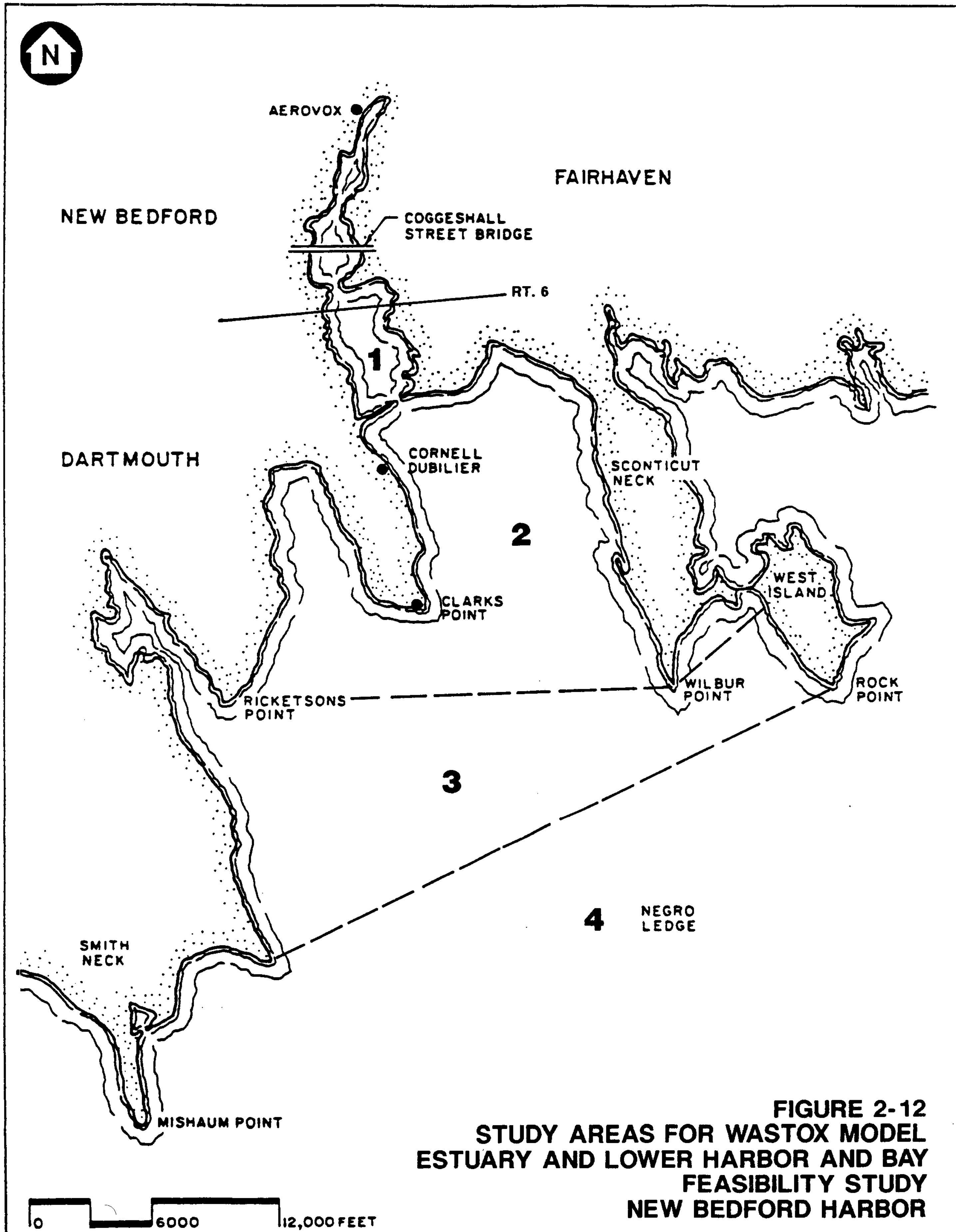


FIGURE 2-12
STUDY AREAS FOR WASTOX MODEL
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

and sediment detrital organic material. Figure 2-13 shows a diagram of the lobster food chain with the fraction of total food consumption assigned to each species. The winter flounder is an omnivore that eats whatever is available, including clams, juvenile crabs, polychaetes and other benthic invertebrates, and phytoplankton. Figure 2-14 is a diagram of the winter flounder food chain with the fraction of total food consumption assigned to each prey. Details on the selection of food chain species and diet distribution are presented elsewhere (Battelle, 1990).

Modifications were made to the original WASTOX code to reflect advancements in the understanding of two biochemical processes: the chemical transfer rate from water to the animal, and the BCF. WASTOX calculates the uptake rate constant for chemical transfer from water to the animal using a diffusivity ratio, which results in a decreasing uptake efficiency as the diffusivity of the chemical decreases. Recent data relating to uptake efficiency and chemical octanol-water partition coefficient (K_{ow}) suggest that efficiency is approximately constant over the range of K_{ow}s that encompasses the PCB homologs (PCB molecules having the same level of chlorination) examined for New Bedford Harbor. To allow for a constant uptake efficiency, the diffusivity ratio was replaced by an uptake efficiency or gill permeability ratio between the chemical and oxygen (Battelle, 1990).

It is now generally accepted that the BCF for neutral organic chemicals is related to the K_{ow} of the chemical and that the lipid-normalized BCF is approximately equal to K_{ow}. Therefore, it is possible to compute a BCF for PCBs in an aquatic animal from the K_{ow} of the chemical and the lipid fraction of the animal. The WASTOX code was modified to calculate the BCF value for each animal and each age class, given the K_{ow} for the chemical and the lipid fraction of the animal (Battelle, 1990).

2.3.2.3 Calibration of the WASTOX Model

The food chain model for New Bedford Harbor was calibrated for PCB Homologs 3, 4, 5, and 6 and for total PCBs (expressed as the sum of Homologs 2 through 9). Total PCB concentrations were computed two ways. First, the summation of the concentrations computed for the homologs was compared to the observed total PCB concentrations as an additional check on the homolog calibrations. Second, total PCBs were calibrated as a separate chemical.

Biota sampling was conducted during the Battelle 1985 field program. Polychaetes, clams, mussels, spider crabs, flounder and lobsters were collected in trawls conducted over all three areas. No biota sampling was conducted in the upper estuary. Samples of species collected during this effort were analyzed

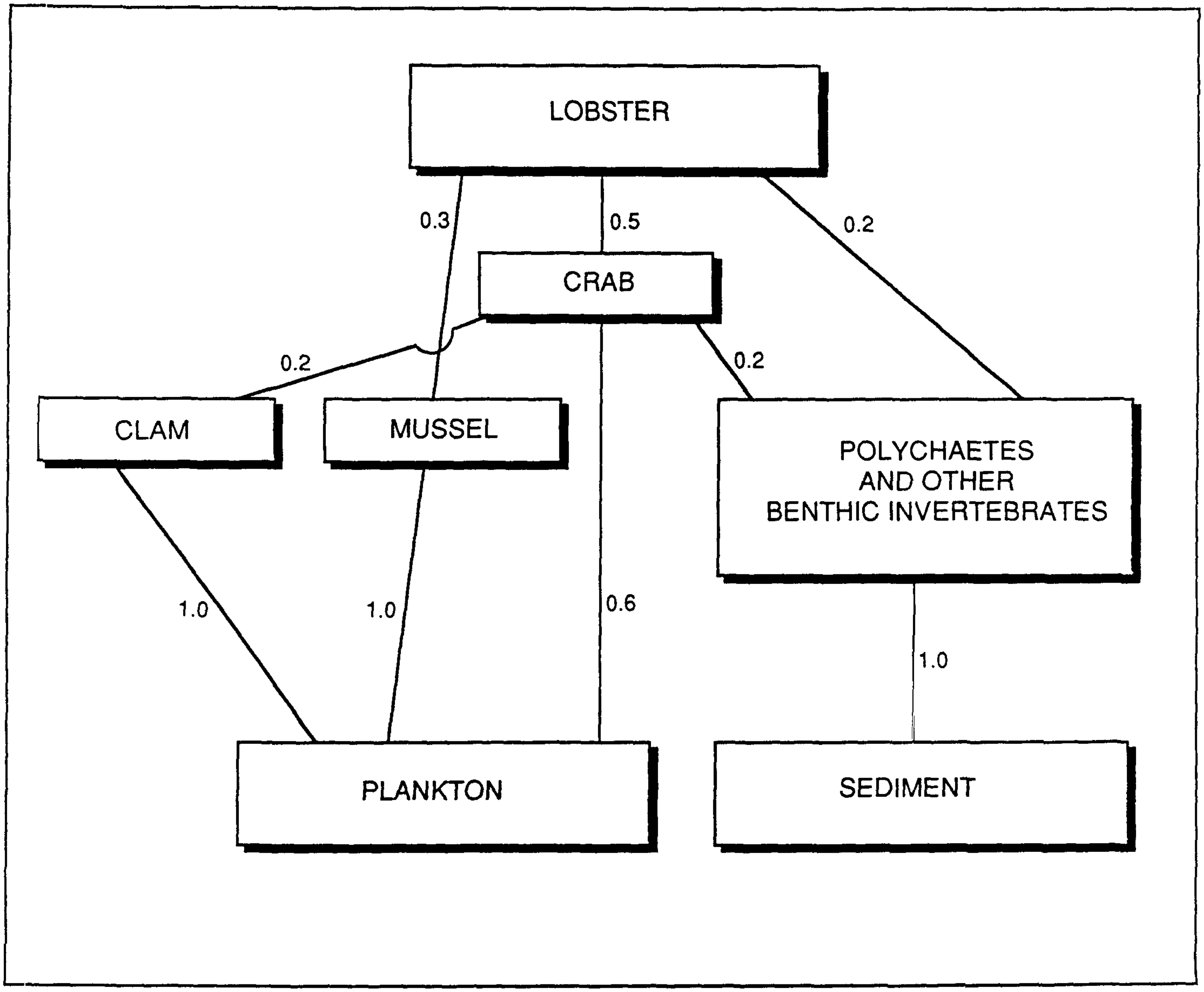


FIGURE 2-13
WASTOX MODEL LOBSTER FOOD CHAIN
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

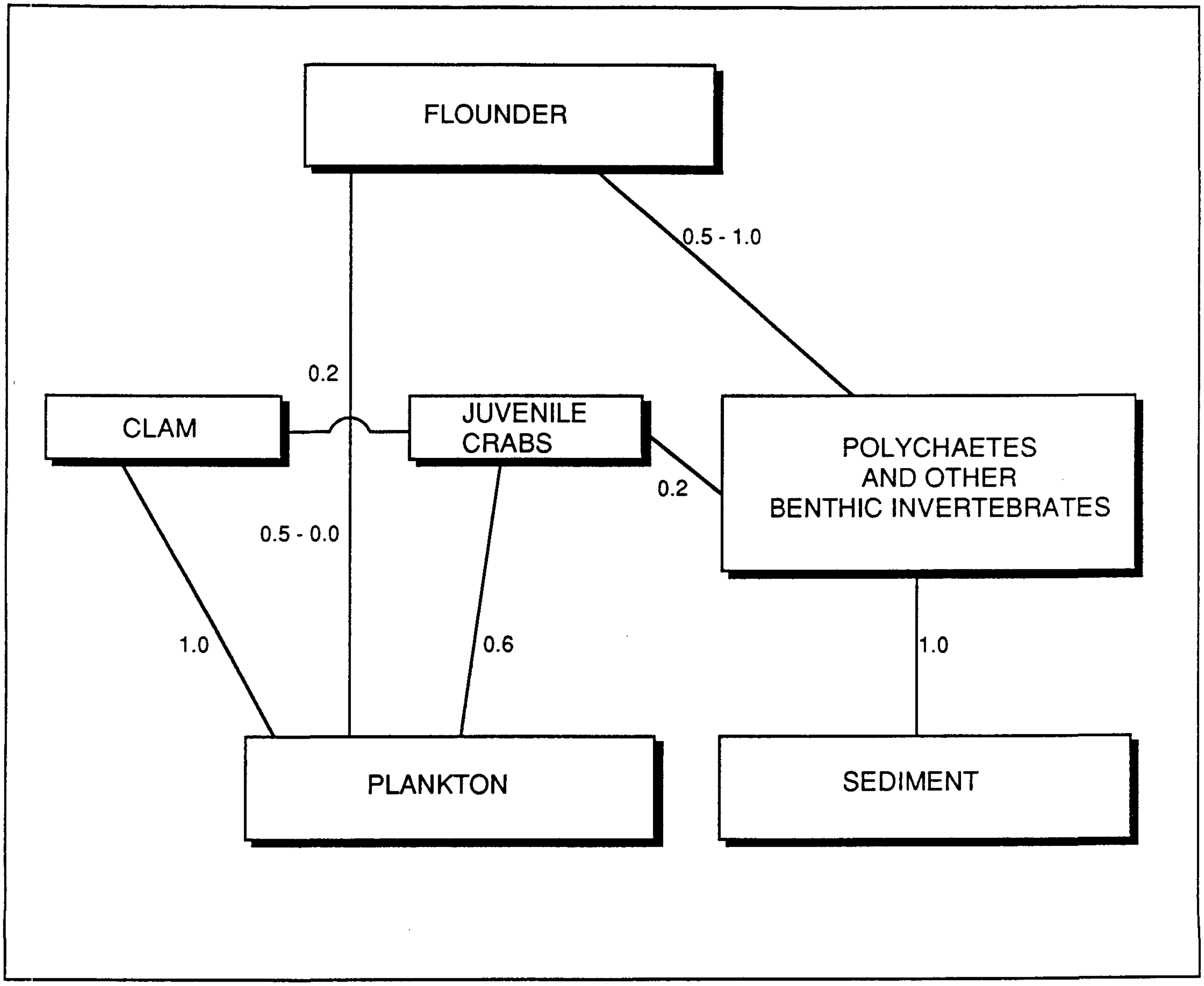


FIGURE 2-14
WASTOX MODEL FLOUNDER FOOD CHAIN
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

for PCB Homologs 2 through 9, and lipid content. All analyses on biota samples were made on whole animals. Biota sampling also helped to establish the distribution of lobster and winter flounder by study area and age.

Arithmetic averages over all size classifications were used in comparing the observed and computed concentrations of PCBs in the animals. The averages of the computed flounder and lobster concentrations were weighted so that the contribution of any age class to the average was consistent with the contribution of that age class to the average of the observed values. For all other species in the food chain, the steady-state computed concentration was compared to the arithmetic average observed concentration. Six age classes of flounder and lobster were included in the model based on the weights of the animals collected during the trawls. The largest flounder age class included animals weighing up to 363 grams and the largest lobster age class included animals weighing up to 773 grams. Lobsters were not modeled in Area 1 because only a single lobster was collected during the field sampling program.

Arithmetic-averaged dissolved and particulate water column and sediment PCB concentrations from the Battelle field sampling cruises in 1984 and 1985 were used as exposure concentrations in calibrating the model. However, averages for Area 1 of the food chain model did not include sampling data collected from stations in the upper estuary where no biota was collected.

The bioenergetic- and chemical-related parameters for each food chain species modeled were based on literature values and remained constant during calibration. These coefficients are independent of the chemical being modeled.

The comparisons between observed and calculated concentrations of PCBs in various biota are presented in Figures 2-15 through 2-19 for Homologs 3 through 6 and total PCBs. Both the observed and calculated values are averaged over all age classes. The observed values are arithmetic means and standard deviations of the combined cruise data.

In general, there was good agreement between the observed data and the calculated concentrations for the homologs and total PCBs. The model successfully reproduced the variation in body burdens across the homologs and over the entire food chain. It also reproduced the spatial concentration gradients evident in the data, although some bias is evident in Areas 3 and 4. In these areas, the computed values fell within the error bars of the data but they were consistently below the mean. It was not possible to achieve a calibration that eliminated this bias without computing unreasonably high concentrations in Areas 1 and 2. Data from Areas 3 and 4 may reflect sampling bias to nearshore or shallow areas, which are more highly contaminated

OBSERVED & COMPUTED PCB HOMOLOG 3 CONCENTRATIONS
IN NEW BEDFORD HARBOR ANIMALS

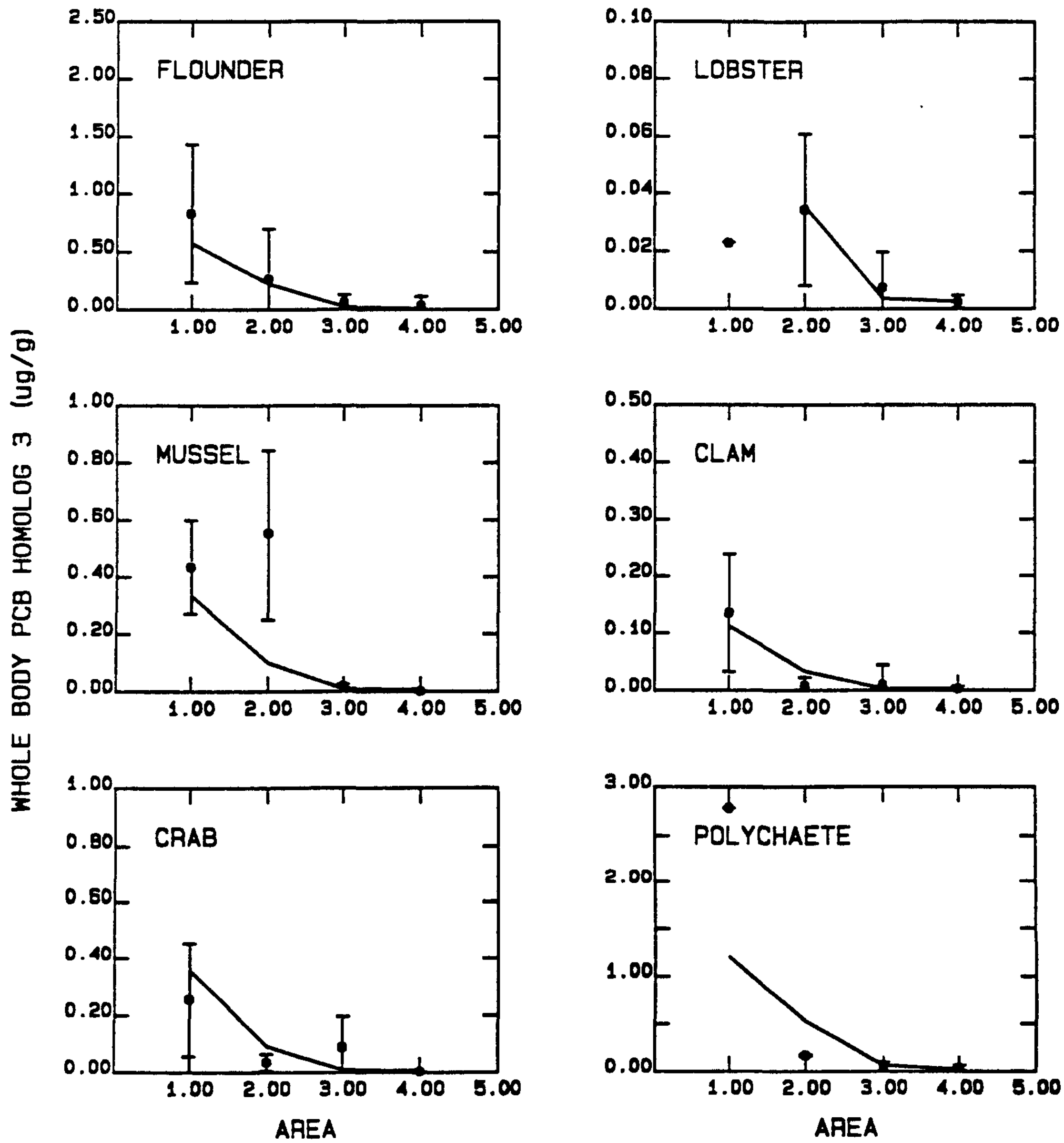


FIGURE 2-15
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

OBSERVED & COMPUTED PCB HOMOLOG 4 CONCENTRATIONS
IN NEW BEDFORD HARBOR ANIMALS

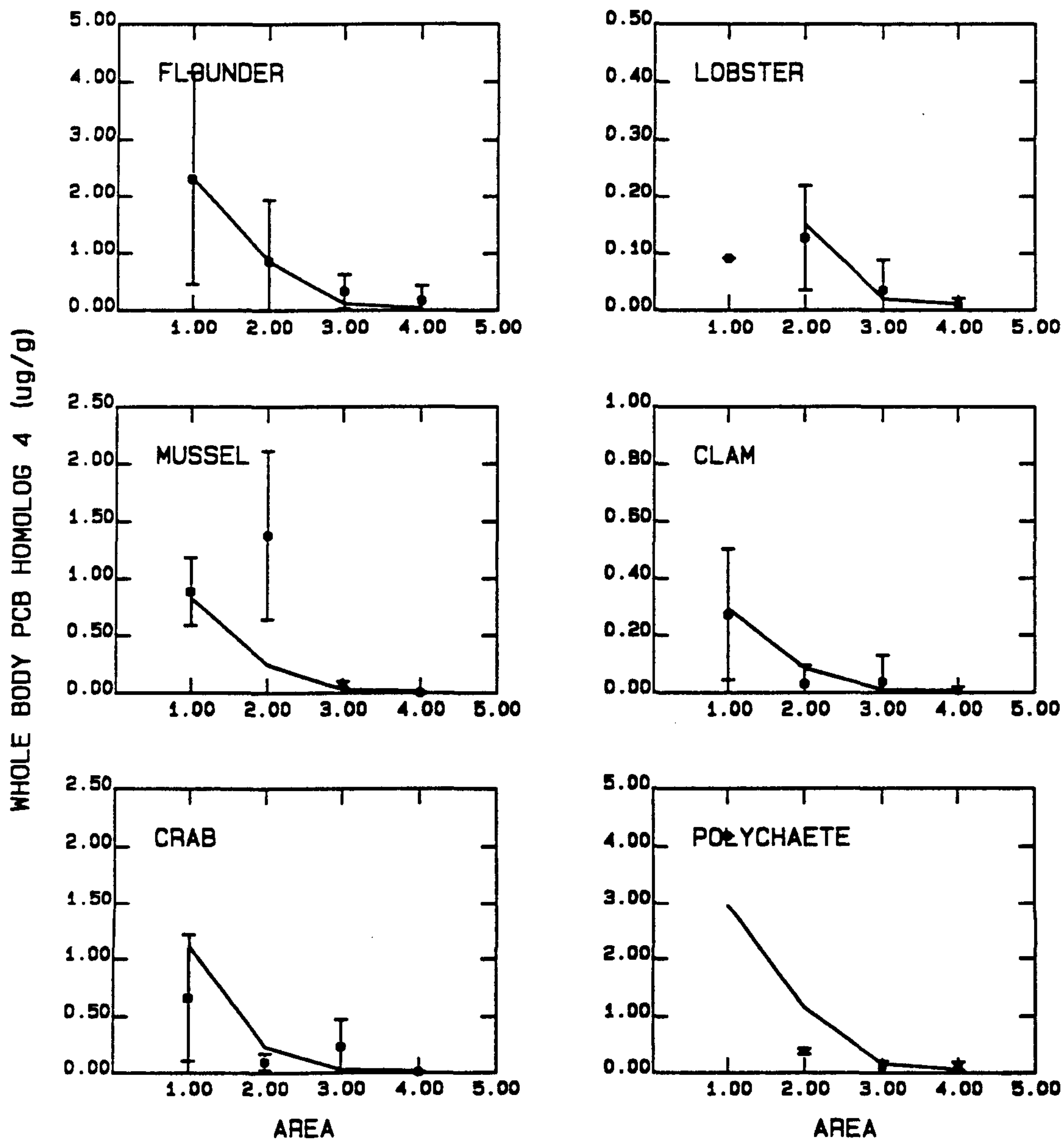


FIGURE 2-16
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

OBSERVED & COMPUTED PCB HOMOLOG 5 CONCENTRATIONS
IN NEW BEDFORD HARBOR ANIMALS

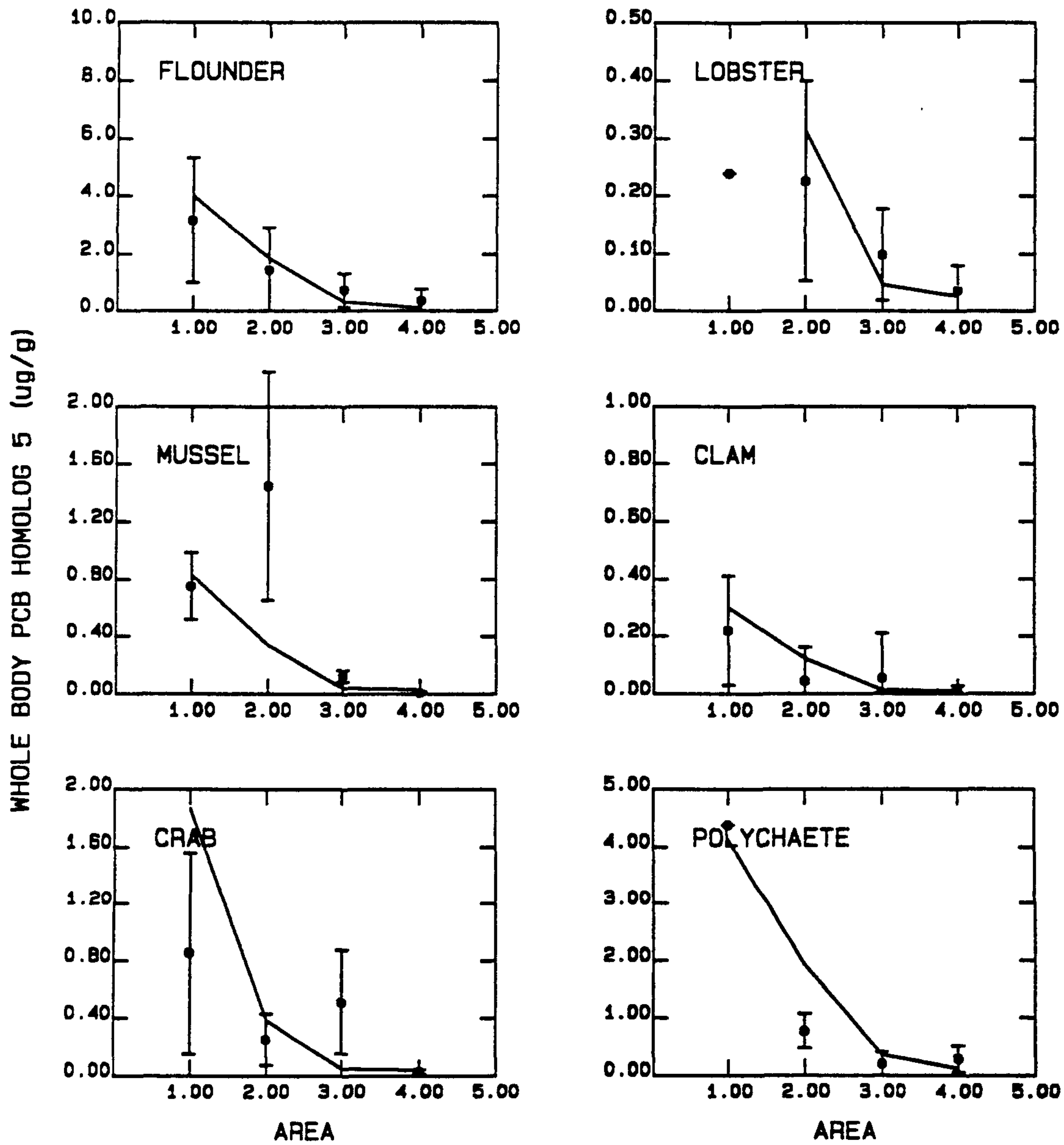


FIGURE 2-17
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

OBSERVED & COMPUTED PCB HOMOLOG 6 CONCENTRATIONS
IN NEW BEDFORD HARBOR ANIMALS

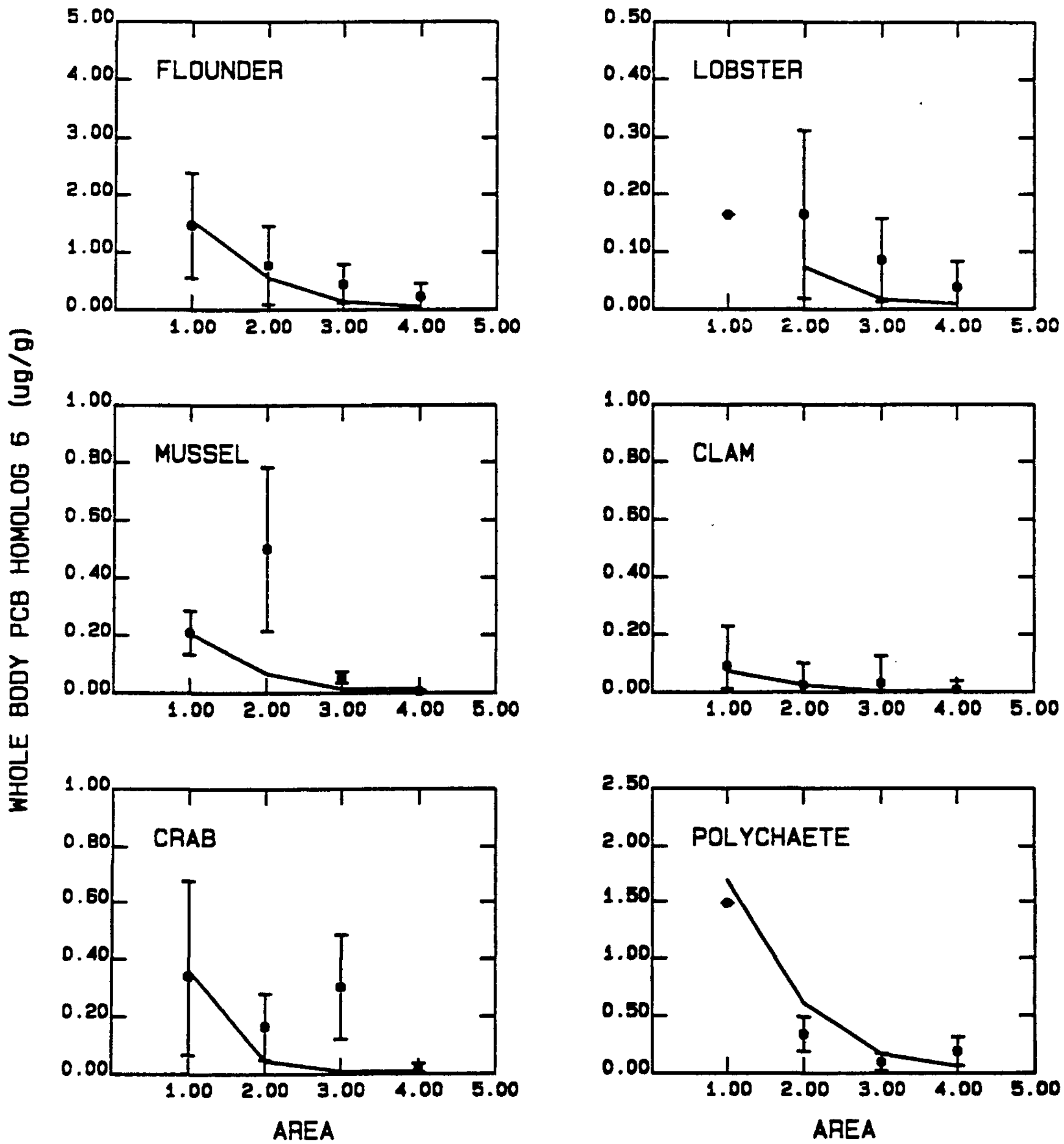


FIGURE 2-18
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

OBSERVED & COMPUTED TOTAL PCB CONCENTRATIONS
IN NEW BEDFORD HARBOR ANIMALS

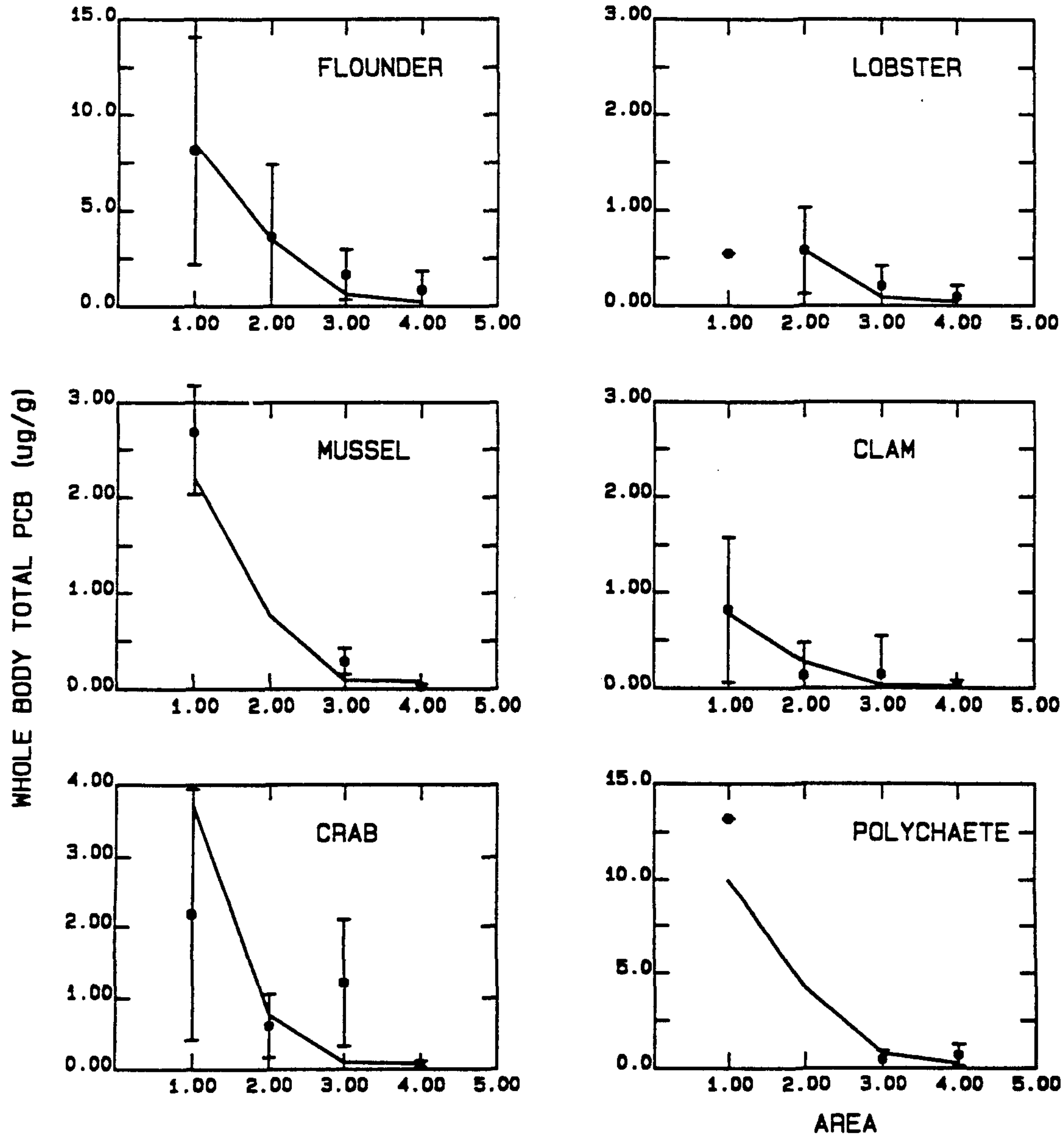


FIGURE 2-19
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

than the stations from which water and sediment samples were taken. Because of the greater significance of model calculations in the more contaminated Areas 1 and 2, the calibration was directed to these areas.

Computed and observed whole-body concentrations in flounder were found to be higher than in lobster. The model indicates that this was due to the higher whole-body lipid content of the flounder and to differences in the food chain structures of these species. The flounder diet, except the first age class, was assumed to be exclusively polychaetes, whereas only 20 percent of the lobster diet is polychaetes. The polychaetes are more highly contaminated than other prey species because of differences in the uptake and loss rates of PCBs and the levels of PCB contamination in the food. The most significant of these differences is lower excretion rates for the polychaete, which result from a higher lipid content and substantially higher PCB concentrations in the sediment consumed by polychaetes than in the phytoplankton consumed by clams and mussels (Battelle, 1990).

2.3.2.4 Long-term Fate

A 10-year projection of the effects of water column and sediment PCB concentrations on biota within the New Bedford Harbor system was evaluated. Water column and sediment PCB concentrations computed during the 10-year no-action TEMPEST/FLESCOT simulation were used as input conditions to the WASTOX model. Details on the interfacing of the two models are presented elsewhere (Battelle, 1990).

The decline in flounder and lobster PCB concentrations will ultimately be equivalent to the decline in exposure concentration. However, the decline in biota PCB concentrations lags the PCB concentrations in water and sediment due to the relatively slow rates of depuration of accumulated PCBs. In addition, the extent of the decline will depend on the relative contribution of water column and sediment PCB to their body burdens because these PCB sources decline at different rates.

The lower levels of the food chain are assumed to be in equilibrium with exposure concentrations. Concentration changes in these animals will be in direct proportion to changes in water column (clams and mussels) or sediment (polychaetes) PCB concentrations, or both (crabs).

Projected concentrations in each age class of winter flounder and lobster relative to time are presented in Figures 2-20 through 2-22. In Area 1 (see Figure 2-20), the PCB concentration in flounder remains constant, ranging from approximately 6.5 micrograms per gram (ug/g) in Age Class 1 to approximately 12 ug/g in Age Class 6. No projection is made for

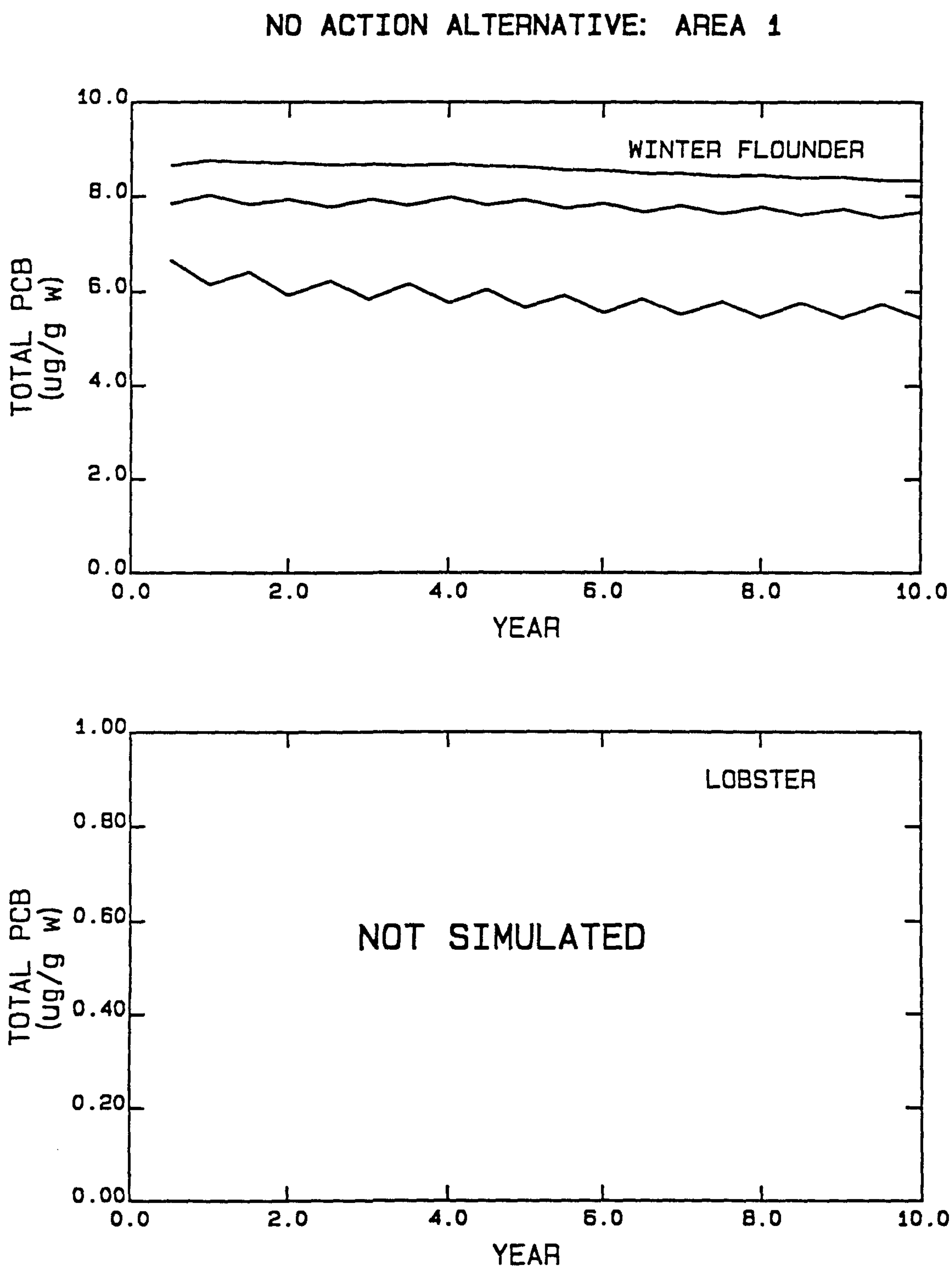


FIGURE 2-20
NO-ACTION ALTERNATIVE: AREA 1
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

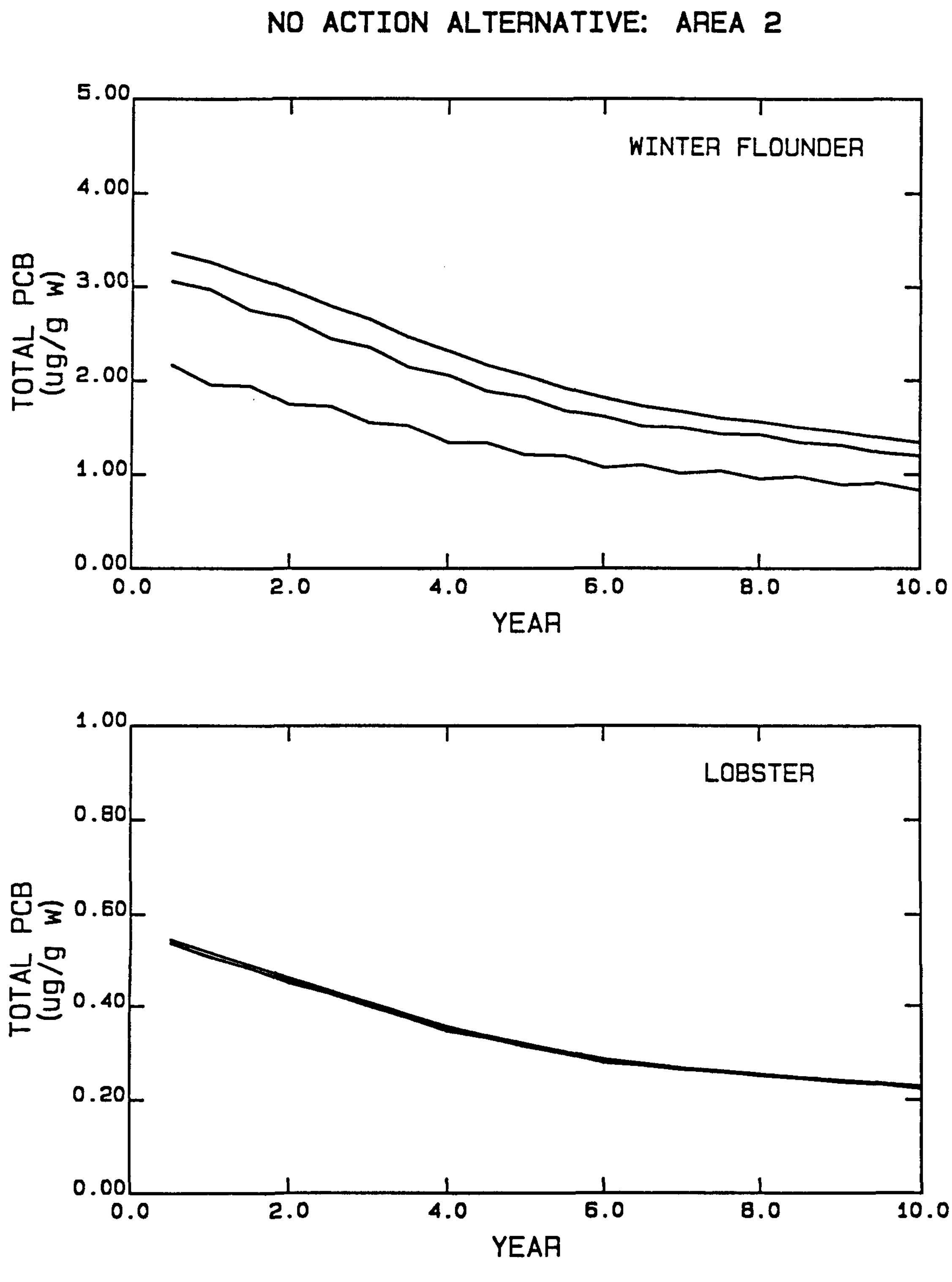
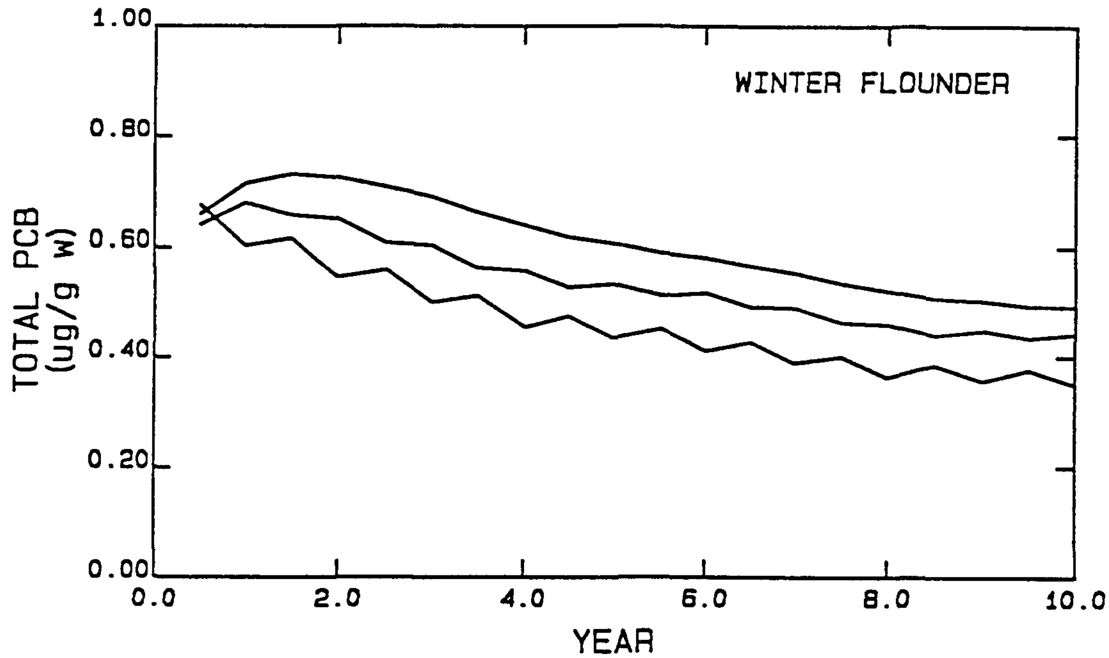


FIGURE 2-21
NO-ALTERNATIVE: AREA 2
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

NO ACTION ALTERNATIVE: AREA 3



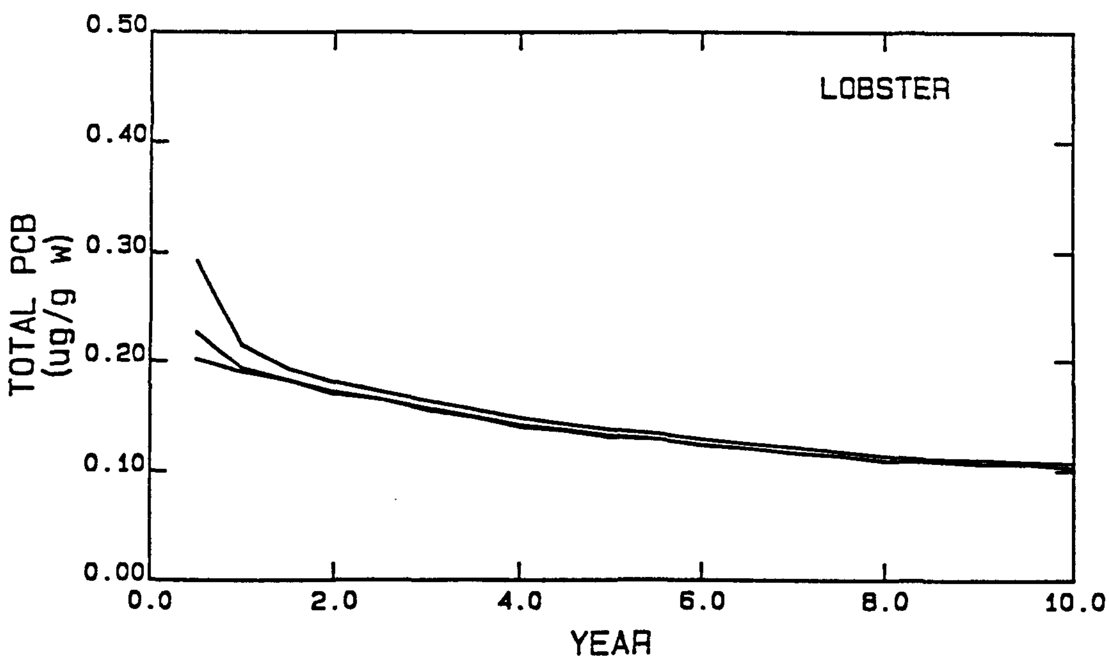


FIGURE 2-22
NO ACTION ALTERNATIVE: AREA 3
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

lobster because the calibration did not include lobster within the inner harbor. The response of the flounder reflects the direct tie to the sediment through consumption of sediment-dwelling organisms (i.e., the polychaete). The flounder is obtaining almost all of the PCBs through ingestion; therefore, it is insensitive to the 30 percent drop in water column PCBs occurring over the 10-year projection. The edible-to-whole-body-PCB ratio of 0.18 for flounder translates the FDA action limit of 2 ug/g edible to 11 ug/g whole body. Therefore, older flounder in Area 1 (Age Classes 3 through 6) are projected to remain close to the action limit (Battelle, 1990).

In Area 2 (see Figure 2-21), a significant drop in concentration occurs in both flounder and lobster. At the end of the 10-year period, concentrations have declined about 60 percent, consistent with declines in the water column and sediment (Battelle, 1990).

Flounder in this area are well below the FDA action limit, even at the start of the projection. The whole-body equivalent of the FDA limit for lobster is 0.22 ug/g. At the start of the projection, lobster are at a concentration about three times the action limit. After 10 years, they have reached levels very near the action limit. The variation in concentration with age class is much less for the lobster than for the flounder. Furthermore, all the age classes group near the action limit. This difference between the species reflects differences in bioenergetics (Battelle, 1990).

2.3.2.5 Other Fate Processes

Naturally occurring physical and chemical processes (e.g., hydrolysis and photo-oxidation) are not expected to significantly reduce the mass of PCBs in the estuary and the lower harbor/bay sediment. Hydrolysis and photo-oxidation are both recognized as attenuative processes for PCBs. However, because of the relatively slow rates at which these processes occur, a significant reduction in sediment PCB concentrations is not expected in a timely manner.

Natural biodegradation of the PCBs in New Bedford Harbor sediments has been investigated as an attenuative mechanism. Natural (or in situ) biodegradation is a process by which contaminants are degraded by indigenous micro-organisms without removing the contaminated medium from its location. The micro-organisms may operate in either an aerobic (oxygen) or anaerobic (oxygen-free) environment.

Recent studies conducted by General Electric Corporation on Hudson River sediment suggest that selective, reductive dechlorination of PCB congeners is occurring slowly via anaerobic microorganisms (Brown and Wagner, 1986). However, the bacterial strains capable of degrading the heavily chlorinated PCB congeners have not been isolated. Researchers at the EPA Gulf Breeze Laboratory reviewed Brown's work and found his conclusions for anaerobic degradation of PCBs in sediment to be reasonable explanations of the data (EPA, 1988).

There is evidence to suggest that anaerobic degradation of PCBs is occurring in New Bedford Harbor sediment. Studies conducted by the EPA-Environmental Research Laboratory (ERL) in Narragansett, Rhode Island, on sediment cores collected from the pilot dredging study area (with PCB concentrations in the 100-ppm range) suggested that anaerobic dechlorination of PCBs is not a significant process at this location (Pruell, 1988). However, ongoing studies conducted by EPA-ERL on estuary sediment samples with PCB concentrations of 500 ppm and higher suggested that significant reductive dechlorination of highly chlorinated PCB congeners was occurring in a manner consistent with Brown's data supporting anaerobic processes (Pruell, 1988).

These findings suggest that anaerobic degradation of sediment PCBs may be occurring more readily in highly contaminated sediment (i.e., greater than 500 ppm); however, little or no anaerobic degradation is occurring in sediment with low PCB concentrations (i.e., less than 500 ppm). Research conducted by Brown and Wagner focused on the comparison of congener composition in commercial PCB products (e.g., Aroclors) with the congener distributions in New Bedford Harbor sediment as a means of supporting their contention for anaerobic degradation (Brown and Wagner, 1986). However, it has been suggested that depletion and shifts in congener distributions can also result from various physical and chemical processes, such as differential adsorption, volatilization, hydrolysis, and photo-oxidation (Myers and Zappi, 1989).

Although biodegradation of PCBs in New Bedford Harbor sediment appears to be occurring, the studies conducted to date have not provided sufficient data for a reliable estimation of biochemical decay rates or half-lives, as well as the toxicity of the decay products. More information is needed to evaluate the length of time that would be required for removal of PCBs from the Hot Spot Area sediment by natural biological processes. Brown suggested that the half-life of anaerobic degradation of heavily chlorinated PCBs may range from seven to 50 years (Brown and Wagner, 1986). Based on this estimate, the time required for biodegradation to reduce a sediment PCB concentration of 4,000 ppm to 50 ppm (i.e., the TSCA limit) would be approximately 50 to 350 years. For PCB sediment concentrations in the 100,000-ppm range (measured in the Hot Spot Area), biodegradation could take approximately 85 to 600 years to reduce these concentration levels to 50 ppm.

3.0 SUMMARY OF BASELINE PUBLIC HEALTH AND ECOLOGICAL RISK ASSESSMENT

As part of the New Bedford Harbor Superfund FS, baseline risk assessments were conducted to identify the public health and environmental risks associated with contaminant exposure within the New Bedford Harbor site area. The draft final baseline public health risk assessment was released in August 1989, and the baseline ecological risk assessment was released in April 1990.

The New Bedford Harbor site area was divided into three areas to assess the potential for exposure and subsequent public health and ecological risks. These areas, shown in Figure 3-1, were defined as follows:

- Area I: The area between the Wood Street and Coggeshall Street bridges
- Area II: The area between the Hurricane Barrier and the Coggeshall Street Bridge
- Area III: The area south of the Hurricane Barrier

For the assessment of risks associated with fish consumption, fish sampling data from beyond Area III were also included. All of Areas II and III are contained within the study area defined as the lower harbor/bay.

The public health and ecological risk assessments are based on current conditions and will serve as the basis for evaluating the various remedial alternatives. The baseline risk assessment is summarized in the following subsection.

3.1 SUMMARY OF BASELINE PUBLIC HEALTH RISK ASSESSMENT

The purpose of the baseline public health risk assessment was to estimate risks to public health under current conditions due to exposure to PCBs and metals detected in the sediment, surface water, and biota within the New Bedford Harbor site. PCBs, cadmium, copper, and lead were all found in sediment at elevated levels compared to data gathered in uncontaminated areas. These contaminants were the focus of the quantitative risk evaluation. The risk assessment is based on existing site conditions and does not consider potential natural decrease in contaminant concentrations due to transport and degradation through time (see Section 2.0).

Data on the distribution of PCBs and metals in the study area were provided by Battelle Pacific Northwest Laboratories (PNL). The public health risk assessment was based primarily on a data set developed as the initial conditions, established by PNL,

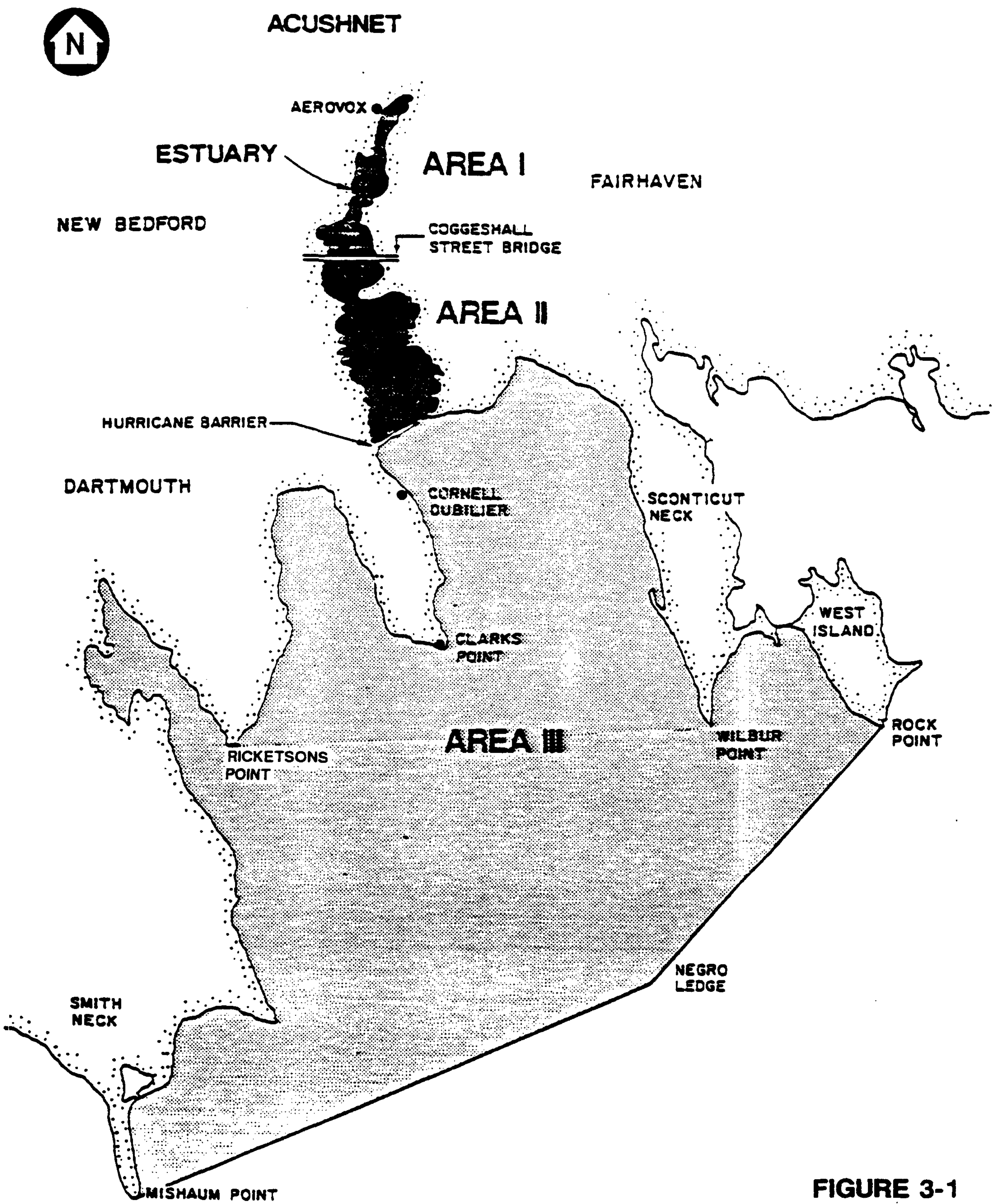


FIGURE 3-1
AREAS USED TO ASSESS HUMAN EXPOSURE TO WATER AND SEDIMENT ESTUARY AND LOWER HARBOR AND BAY FEASIBILITY STUDY NEW BEDFORD HARBOR

4959-22

using information obtained from Battelle Ocean Sciences (BOS), GCA Corporation (now Alliance Technologies Corporation), and NUS. These data bases are discussed in the Baseline Public Health Risk Assessment (Ebasco/E.C. Jordan Co., 1989b). Additional information used includes various site investigation reports, the Greater New Bedford Health Effects Study, the Pilot Study conducted by USACE, and the Damage Assessment Report prepared for the National Ocean and Atmospheric Administration.

3.1.1 Methodology

Public health risks were evaluated at specific locations within Areas II and III, where activities likely to result in exposure occur (e.g., swimming, wading, and fishing). Separate risk estimates were developed for Area I (the cove area and the upper and lower estuary) and are discussed in the Hot Spot FS.

Exposure was evaluated at Popes, Palmer, and Marsh islands located in Area II; and at the Fort Rodman and Fort Phoenix state beaches located in Area III (Figure 3-2). All these locations have unrestricted access and most support recreational activities.

Based on results of a screening process designed to identify pathways of exposure at the New Bedford Harbor site, direct contact and incidental ingestion of shoreline sediment and ingestion of aquatic biota were selected as the exposure pathways of primary concern (E.C. Jordan Co./Ebasco, 1989a). The PCB and metals shoreline sediment concentrations in these areas are presented in Table 3-1.

Screening results showed that under worst-case conditions, exposure to PCBs and metals in the surface water does not result in significant contaminant exposure; therefore, this pathway was not evaluated further in the risk assessment.

Limited data were available to assess risks associated with inhalation exposure to metals and PCBs. The available air data for the risk assessment were viewed as representing a "snapshot" of contaminant levels in the area (NUS, 1986). Cadmium, lead, and PCBs were the only contaminants of concern for which air data are available. Cadmium was not detected in any samples and lead concentrations were too low to make a precise determination of ambient levels. Therefore, exposure to these contaminants was not evaluated. PCB concentrations ranged from below detection limit to 471 nanograms per cubic meter (ng/cm). Because sample locations were selected to monitor the air in the mudflat area of the upper estuary, these data may not be representative of exposure concentrations in the lower harbor/bay. Therefore, baseline risks were estimated based on an assumed "background" concentration of 10 ng/cm PCB (NUS, 1986). The carcinogenic risks associated with 70-year exposure to this concentration was

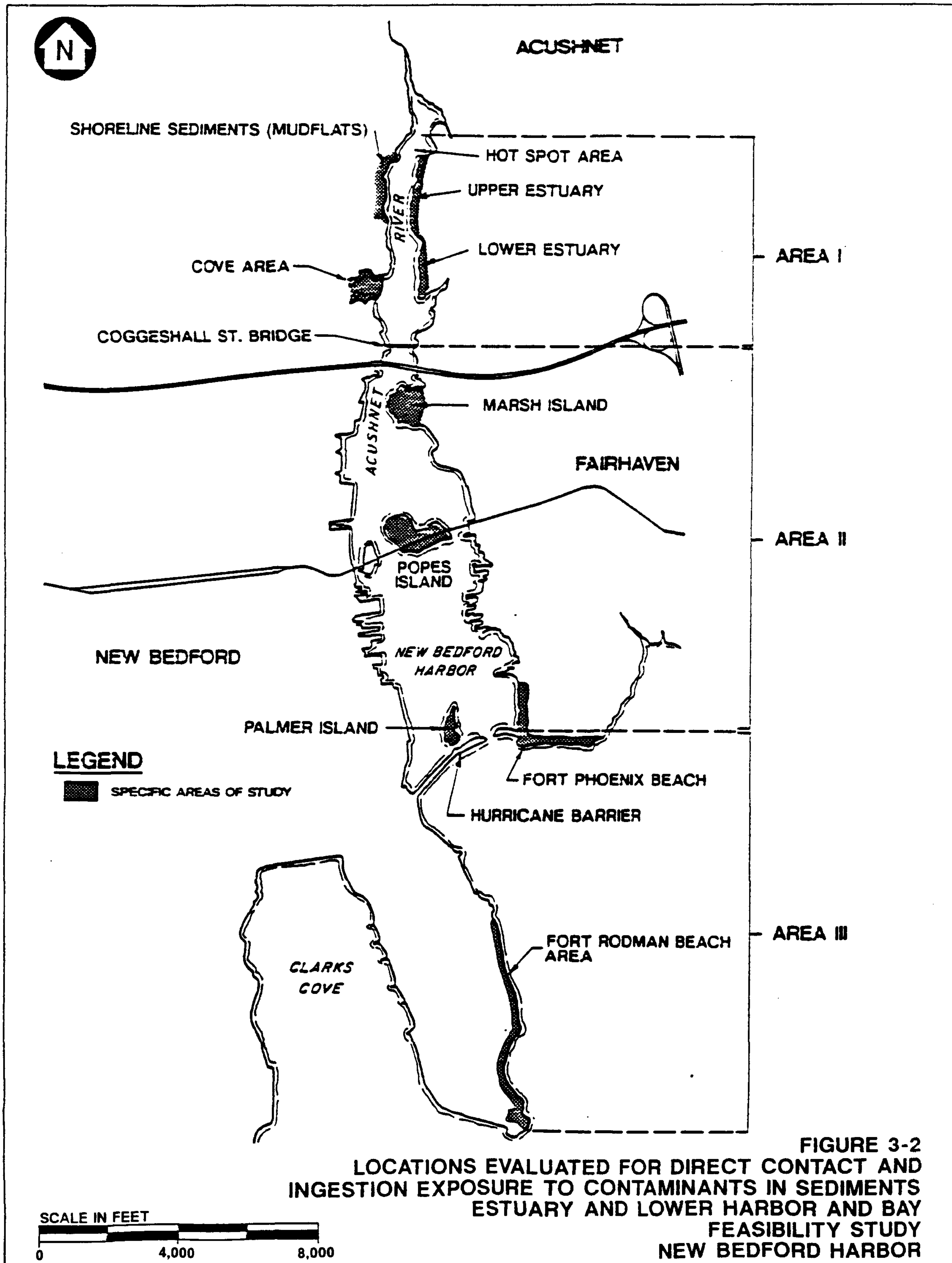


FIGURE 3-2
LOCATIONS EVALUATED FOR DIRECT CONTACT AND INGESTION EXPOSURE TO CONTAMINANTS IN SEDIMENTS
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-22

TABLE 3-1

PCB AND METALS SEDIMENT CONCENTRATIONS (ppm) USED
TO ASSESS DIRECT CONTACT AND INGESTION EXPOSURES

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

	PCBs		CADMIUM		COPPER		LEAD	
	MEAN[a]	MAXIMUM	MEAN[b]	MAXIMUM	MEAN[b]	MAXIMUM	MEAN[b]	MAXIMUM
AREA I								
Shoreline Concentrations								
Entire Area	378	6,393	19.2	69	591	3,180	384	1,680
Upper Estuary	378	6,393	18.8	69	588	1,900	445	1,680
Lower Estuary	149	399	20	63	598	3,180	278	1,330
AREA II								
Shoreline Concentrations								
Entire Area	21	125	7.6	14	570	2,790	160	559
Palmer Island	3	11	ND	ND	310	310	139	139
Popes Island	11	34	ND	ND	492	771	156	272
Marsh Island	8	22	ND	ND	300	463	191	323
AREA III								
Shoreline Concentrations								
Entire Area	4	29	ND	ND	94	154	55	106
Fort Rodman Beach Area	2	7	NA	NA	NA	NA	NA	NA
Fort Phoenix Beach Area	0.59	0.75	NA	NA	NA	NA	NA	NA

Notes:

[a] = Mean concentration for PCBs represents the geometric mean value detected in each area.
[b] = Mean concentration for metals represents the arithmetic mean value of the concentrations detected in each area.
Maximum concentration represents the maximum value detected in each area.
NA = Not Available; shoreline sediment data for metals were unavailable.
ND = Not Detected

3.88.80
0010.0.0

$8x10^{-6}$. The significance of this route of exposure can be reevaluated as additional data becomes available.

Noncarcinogenic and carcinogenic risks were evaluated in the baseline risk assessment. Noncarcinogenic risk estimates were developed to assess the toxicity from exposure to PCBs, cadmium, copper, and lead. These estimates were generated by comparing the Chronic Daily Intake (CDI) of a contaminant to the most applicable health-based criterion (e.g., reference dose [RfD]) or standard (e.g., Maximum Contaminant Level [MCL]). The ratio of these values (CDI/RfD) was used to evaluate risk; in this report, the ratio is referred to as the risk ratio.

Generally, EPA states that if the ratio is less than 1, the predicted body dose level is anticipated to be without lifetime risk to human health (EPA, 1986). For example, a value of 0.25 implies that a person is receiving an estimated average daily dose equal to 25 percent of the acceptable intake of that contaminant. If the ratio exceeds 1, the estimated average daily dose levels exceed a level considered safe; therefore, the exposure could potentially result in adverse health effects.

Carcinogenic risk estimates for PCBs (classified by EPA as a probable human carcinogen [Group B2]) were calculated by multiplying the potency factor for PCBs (expressed as $(mg/kg\text{-}day)^{-1}$) by the estimated body dose (expressed as mg/kg-day) of PCBs. The product of these two values represents a conservative estimate of incremental lifetime cancer risk. This risk is defined as the excess probability that an individual will develop cancer over a lifetime under the assumed conditions of exposure.

EPA guidance states that the target total estimated carcinogenic risk for an individual resulting from exposure at a Superfund site may range from 10^{-4} to 10^{-6} (NCP, 55FR8666). In addition to EPA guidance on evaluating health risks at Superfund sites, the Commonwealth of Massachusetts has issued regulations in the Massachusetts Contingency Plan (MCP) that are applicable to the site. The portion of the MCP relevant to this risk assessment requires a permanent solution to be implemented at all disposal sites that effectively eliminates significant or otherwise unacceptable risks to health, safety, public welfare, or the environment. As stated in the MCP, the total site cancer risk should be compared to a cancer risk limit of 1 in 100,000 (10^{-5}). The total site noncarcinogenic risk should be compared to a risk limit represented by a Hazard Index (HI) equal to 0.2. (An HI for a particular exposure pathway is equal to the sum of the risk ratios estimated for individual chemicals.)

The risk estimates generated in the baseline risk assessment were evaluated using the EPA guidance levels and MCP criteria.

Response objectives and remedial alternatives are developed as part of the FS to reduce total carcinogenic risks to levels within this range.

3.1.2 Results of the Public Health Risk Assessment for the Lower Harbor/Bay

Numerous risk estimates were developed as part of the baseline public health risk assessment based on potential contaminant exposure via direct contact and incidental ingestion of shoreline sediments and ingestion of biota. Because the concentrations of contaminants and the potential for exposure vary greatly by location within the New Bedford Harbor site, separate risk estimates were generated for the three areas shown in Figure 3-1, as well as the specific locations within a given area (see Figure 3-2). Of the three areas identified, Areas II and III are contained within the study area defined as the lower harbor/bay. Public health risks associated with exposure to contaminants in Area I were addressed in the Hot Spot FS. Major findings of the baseline risk assessment for the lower harbor/bay are discussed in the following subsections.

3.1.2.1 Sediment

Area II. Most of the shoreline in Area II is not readily accessible. Private property abutting the shoreline is fenced and much of the land use is classified as industrial. However, three locations within this area are accessible and support recreational land uses: Popes, Marsh, and Palmer islands.

The incremental carcinogenic risks associated with contaminant exposure around Palmer Island were greater for children and older children than for adults. Risk estimates based on probable exposure conditions for these age classes ranged from $2x10^{-7}$ to $2x10^{-6}$. Under more conservative exposure conditions, the risk estimates for children were higher, ranging from $4x10^{-6}$ to $4x10^{-5}$.

The concentration distribution of PCBs in shoreline sediment from Palmer Island shows that 93 percent of the PCB concentrations are less than 5 ppm, indicating that potential exposure in this area is reflected by the assumptions used in the probable exposure scenario (e.g., exposure to 3 ppm PCB). Because these risk estimates fall at or below the lower end of the target range, exposure in this area is not considered to present a public health risk.

The risk estimates generated for exposure to sediment around Marsh Island were greatest for children and older children, ranging from $5x10^{-7}$ to $5x10^{-6}$ under probable exposure conditions, and $8x10^{-6}$ to $8x10^{-5}$ under conservative exposure conditions.

The concentration distribution of PCBs in sediment from the Marsh Island area indicates that 77 percent of the PCB concentrations are less than 8 ppm, similar to the concentration used to assess risk under probable exposure conditions. Risk estimates based on exposure by children to 8 ppm PCBs under probable exposure conditions range from 5×10^{-7} to 5×10^{-6}. These risk estimates fall within the lower end of the target range and are considered reflective of the likely exposure conditions in this area.

The concentrations of PCBs in sediment from Popes Island are higher than those detected at either Marsh or Palmer island. The risks associated with exposure to this sediment are within or slightly above the target range, with two scenarios exceeding a 10^{-4} lifetime cancer risk. The incremental carcinogenic risks were greatest for children and older children. These risks ranged from 8×10^{-7} to 8×10^{-6} under probable exposure conditions, and from 1×10^{-5} to 1×10^{-4} under conservative exposure conditions. Because the 50th percentile of PCB concentrations from this area is greater than the concentration used to evaluate risk under probable exposure conditions, the risks developed under the conservative scenarios are considered to reflect likely exposure conditions in this area.

Noncarcinogenic risks associated with direct contact exposure to metals-contaminated sediment were not considered to present a public health risk. The multitoxic risk ratio (or HI) based on concurrent exposure to cadmium, copper, and lead were all below 0.2 under both conservative and probable exposure conditions. Exposure through ingestion of metals-contaminated sediments was associated with HI values in excess of 0.2. The majority of risk was associated with exposure to lead.

Area III. Direct contact exposure to PCBs in sediment in Area III was assessed for the Fort Rodman and Fort Phoenix state beach areas (see Figure 3-1). Risk estimates based on exposure to shoreline sediments fell within or below the target range (i.e., 2×10^{-8} to 3×10^{-5} for probable and conservative exposure assumptions, respectively). Noncarcinogenic risks associated with metals exposure were not considered to present a public health risk.

3.1.2.2 Biota

Exposure to PCBs through ingestion of biota was assessed based on concentrations detected in lobster, winter flounder, and clams. These species were considered representative of the biota most commonly consumed in the New Bedford Harbor area. Edible-tissue PCB concentrations were used when available. The range of PCB concentrations evaluated in this risk assessment was 0.039 to 2.7 ppm (Battelle, 1989). Exposure frequencies of one fish meal per day, per week, and per month were assumed. A fish meal was considered to be an 8-ounce (227 grams) portion for older children and adults, and a 4-ounce (115 grams) portion for younger children.

The risks from exposure to contaminants via ingestion of biota were greatest for children. Both noncarcinogenic and carcinogenic risks were estimated to be in excess of EPA and state guidelines. The risk ratios calculated based on weekly ingestion of biota by a child, and concurrent exposure to the mean PCB and metals concentrations detected in the three species, ranged from 4 to 28. This range increased to 14 to 85 when assuming exposure to the maximum contaminant concentration detected in each species. The majority of risk was associated with exposure to PCBs and lead. The carcinogenic risk estimates for a child (chronic exposure to PCBs) range from $4x10^{-5}$ to $8x10^{-3}$ for biota collected in Area II; $3x10^{-5}$ to $5x10^{-3}$ for biota collected in Area III; and $8x10^{-6}$ to $2x10^{-3}$ for biota collected in Area IV (E.C. Jordan Co./Ebasco, 1989a).

3.2 ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment for the New Bedford Harbor site examined potential risks to marine biota due to exposure to PCB and metals contamination in sediment and in the water column. The focus of this document concerns the effects of contamination in the lower harbor/bay.

3.2.1 Methodology

EPA defines ecological risk resulting from exposure to toxic contaminants to include both direct risks to the growth, reproduction, or survival of the ecological receptor species, as well as risk that the resource value of any species will be reduced as a result of contaminant body burdens. Although both aspects of risk are considered in the baseline risk assessment, the focus of this risk assessment is on the direct risks.

Ecological risks in New Bedford Harbor were determined by a mathematical evaluation and combination of two factors: the degree of exposure to contaminants at the site and the ecotoxicity of PCBs and the three metals to aquatic organisms. Ecological risk was then quantified as the probability of impact on specific taxonomic groups representing the major ecotypes present in the harbor.

Twenty-eight species were identified as aquatic receptors in the harbor (E.C. Jordan Co./Ebasco, 1990). These species, considered representative of the range of organisms in New Bedford Harbor, included species from each major trophic level. Routes of exposure considered in the assessment included direct contact with water and sediment, and ingestion of contaminated food. EPA AWQC, laboratory-derived toxicity data, and site-specific toxicity data (when available) were used in the risk assessment.

Exposure to contaminated sediment and contaminants in the water column was evaluated separately for each of the five harbor areas (i.e., Zones 1 through 5). Zone 1 represents the estuary, and all of Zones 2, 3, 4, and 5 represent the study area defined as the lower harbor/bay. The area boundaries correspond to those in the Battelle chemical/physical transport model, and are identified in Figure 3-3.

Risk to aquatic biota was evaluated using a joint probability analysis in which two probability distributions, one representing contaminant levels in various zones of the harbor and the second representing the sensitivity of biota to contaminants, were combined to present a comprehensive probabilistic evaluation of risk. The statistical comparison of these distributions permit the generation of probabilities that the toxicological benchmarks would be exceeded in a particular area. PCB exposure concentrations were calculated from the initial conditions sediment concentration data for the physical/chemical model using partition coefficients (k_d). Values for site-specific apparent k_ds in New Bedford Harbor are available from experiments conducted by BOS and literature review (Brownawell and Farrington, 1986).

The joint probability analysis was supplemented by comparison of PCB levels in New Bedford Harbor to EPA AWQC, evaluation of site-specific toxicity tests, and examination of data on the structure of faunal communities in the harbor.

Body burden of PCBs, cadmium, copper, and lead was evaluated for these same five zones by comparing observed tissue concentrations in biota with species-specific toxicity data.

3.2.2 Results of Environmental Baseline Assessment

Results of these various approaches to evaluating risk support, both together and independently, the conclusion that aquatic organisms are at significant risk due to exposure to PCBs in New Bedford Harbor. Some risk due to exposure to metals was also identified but was negligible in comparison to the risk due to PCBs.

Concentrations of dissolved PCBs in all areas of the inner harbor (i.e., north of the Hurricane Barrier) were sufficiently elevated to result in a significant likelihood of chronic effects to indigenous biota. PCB concentrations in sediment and sediment pore water in many areas of the harbor were found to be highly toxic to at least some members of all major taxonomic groups of organisms.

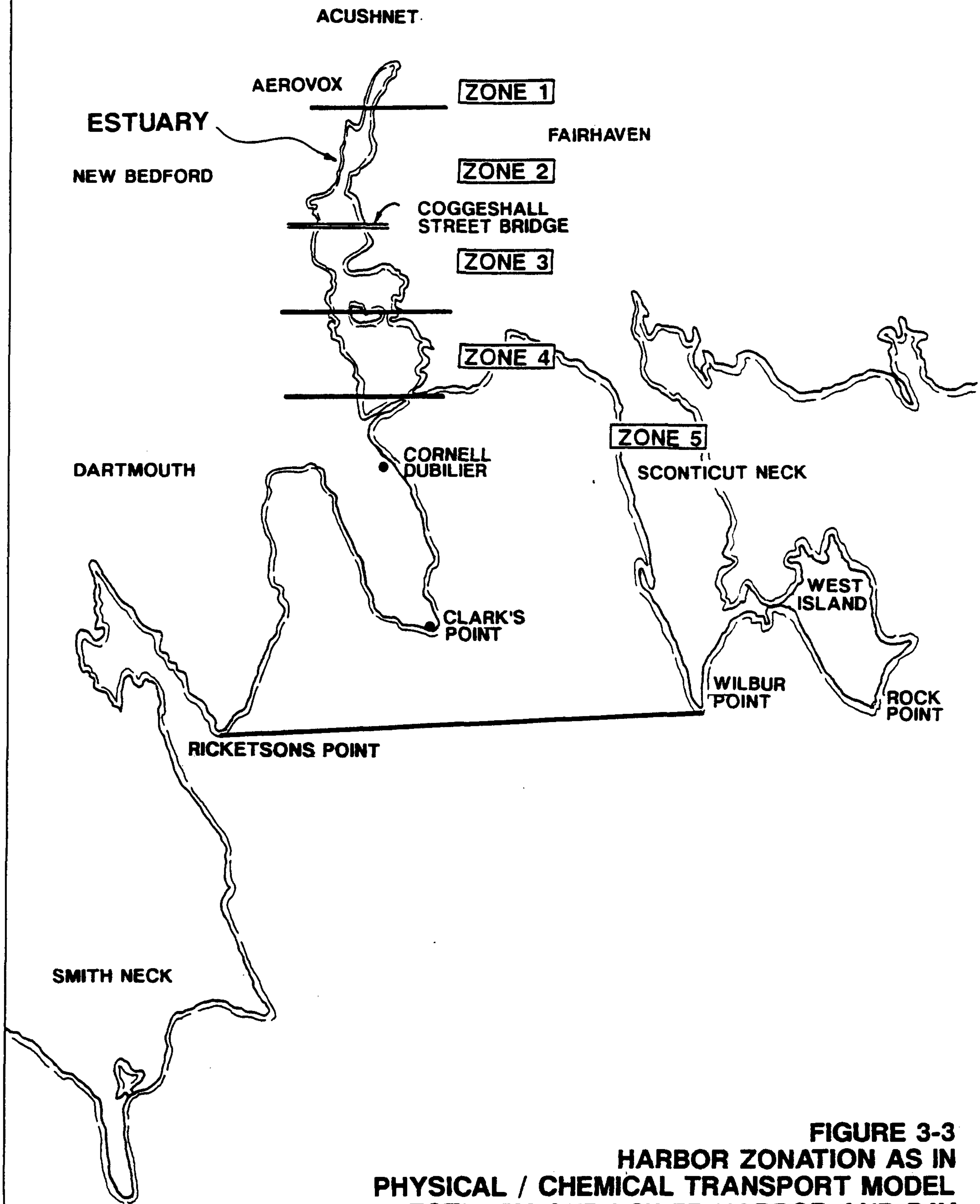


FIGURE 3-3
HARBOR ZONATION AS IN
PHYSICAL / CHEMICAL TRANSPORT MODEL
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

The risk probabilities for all major taxonomic groups suggest that marine fish may be substantially affected in Zones 1 through 5. In addition to the joint probability analysis, comparisons of PCB-sediment concentrations were made to the interim Sediment Quality Criteria (SQC) for PCBs (Aroclor 1254). SQC were developed for a number of hydrophobic organic compounds based on their expected partitioning between sediment organic matter and interstitial water (Field and Dexter, 1988). These SQC were developed by the Criteria and Standards Division of EPA to provide numerical standards for sediment-bound contamination, which are designed to protect aquatic life (Field and Dexter, 1988). The upper and lower 95 percent confidence intervals (CIs) for the SQC represent the range within which the actual sediment criteria value is expected to fall. The lower CI value is taken to represent the concentration which, with 97.5 percent certainty, will result in protection from chronic effects. The mean sediment concentrations in each zone were compared to the lower-bound 95 percent CI and the maximum concentration compared to the PCB SQC. Assuming an average TOC concentration of 1 percent in the sediment, the carbon-normalized SQC is 418 micrograms per kilogram (ug/kg), with a lower-bound CI of 82.9 ug/kg. These results suggest that PCB concentrations in Zones 1 and 2 pose a significant risk to aquatic organisms in New Bedford Harbor.

Measured PCB concentrations in winter flounder (i.e., body burdens) from all areas of New Bedford Harbor were found to exceed levels determined by Black and Capuzzo to correlate with reproductive effects or growth rate reductions (Black, 1986; and Capuzzo, 1986). These effects were found to occur at organ-specific concentrations in winter flounder as low as 0.1 ppm. PCB levels in gonadal tissue of winter flounder collected from Zones 1, 2, and 3 exceed these levels.

The joint probability analysis for metals and the comparison of metals concentrations to AWQC indicate a potential risk to marine biota. Concentrations of copper in the water column exceeded the applicable criterion. Crustaceans were determined to be the taxon most likely at risk from copper exposure. Although exposure to metals may result in deleterious impacts on the harbor ecosystem, the effects of PCB exposure are considered far greater and more significant.

Based on these evaluations, it is probable that the structure and function of the New Bedford Harbor ecosystem have been affected by PCB contamination. Levels of PCBs, particularly in Zones 1 and 2, are sufficient to result in mortality, decreased reproduction, and decreased food resources to higher trophic level biota. A study of benthic populations in the harbor indicated impaired community structure in the upper estuary, and toxicity tests conducted by EPA demonstrated the toxicity of sediment from this area to amphipod crustaceans (USACE, 1986; and Hansen, 1986).

Potential community or ecosystem level impacts due to PCBs in New Bedford Harbor cannot be evaluated fully by assessing impacts to individual species or taxonomic groups. However, the state of development of ecological risk assessment methodology does not allow quantification of impacts or risk at these higher levels. Nonetheless, the results of numerous site-specific and laboratory studies, including this risk assessment, indicate that New Bedford Harbor is an ecosystem under stress and there is a high probability that PCBs are a significant contributing factor to the integrity of the harbor as an integrated functioning ecosystem.

Several infaunal surveys have been performed at New Bedford Harbor. Despite the fact that many ecological factors, in addition to chemical contamination, can contribute to areal differences in the numbers and kinds of organisms, these results generally support the conclusion that PCBs are adversely affecting New Bedford Harbor.

An extensive benthic sampling program was conducted for USACE using 26 sampling locations spanning all areas of the harbor (USACE, 1986). Significant correlations between the level of PCB contamination in the harbor and several measures of community, including the number of species, and diversity and evenness indices were found. Due to differences in the sampling methodology used during the program, there is some concern regarding comparability of the sampling data. However, the overall trends relating benthic community descriptors to PCB levels appear to be robust. The basic pattern observed was a domination in the Upper Estuary by the polychaete, <u>Streblospio benedicti</u>, with another polychaete, <u>Tharyx acutus</u>, being dominant in the rest of the inner harbor. Outside the Hurricane Barrier, bivalves and gastropods became the most common organisms. Associated with these taxonomic differences were an increase in the species diversity of the infaunal community, and a more equal representation of individual species, from the upper estuary into the outer harbor.

A comparative study of this nature suffers from the gross differences in habitat between different locations. It is possible that physical factors (e.g., sediment characteristics and turbidity) are the primary determinants of the community patterns observed. However, these results do not contradict the conclusions arrived at previously regarding risks associated with different zones. Polychaetes are, in general, less sensitive to sediment contamination than other taxa (Rubinstein, 1989); their general domination of the most highly contaminated sediments at the harbor is suggestive of the impact that PCBs and other chemicals may be having on this ecosystem.

A wetland study compared chemical and biological data from six wetland areas in New Bedford Harbor and from a relatively unpolluted reference area in Buzzards Bay (IEP, Inc., 1988). They found a depauperate benthic community in the Zone 1 wetland. In addition, a comparison of the biological data between a Zone 2 wetland with the reference area indicated significant differences in species diversity and evenness, particularly among polychaetes, amphipods, and mollusks. However, habitat differences complicate any attempt to relate differences in benthic community patterns to variation in the PCB contamination between these locations.

3.3 OTHER APPROACHES TO EVALUATING ECOLOGICAL RISK

The joint probability analysis and SQC comparison used in the baseline risk assessment for New Bedford Harbor are two of many methodologies available to evaluate ecological risk. Unlike public health risk evaluations, a single approach has not yet been established. This is due in part to the difficulties in predicting and evaluating the effects of contamination on an ecosystem. Each ecosystem has unique biotic and abiotic characteristics that must be understood to evaluate potential effects from contaminant exposure. It is therefore not possible to establish standardized exposure parameters or methodologies suitable for "ecological risk evaluations." As such, different investigators have proposed various methods for evaluating potential ecological effects.

Other valid approaches are described in the following subsections for both comparative purposes and to assist in determining the need for and extent of remediation at this site. These four additional approaches are considered appropriate for evaluating risks to aquatic ecosystems such as New Bedford Harbor.

3.3.1 Equilibrium Partitioning

The Equilibrium Partitioning (EP) approach compares predicted interstitial water concentrations derived from EP theory and observed sediment contaminant levels to existing water quality criteria (e.g., AWQC). Acceptable contaminant concentrations or ranges of concentrations based on the AWQC or other criteria can be established. For New Bedford Harbor, the K_ds for the different Aroclors can be used to estimate acceptable sediment PCB concentrations. Using the AWQC of 0.03 micrograms per liter (ug/L) PCB, the total PCB concentration in sediments is 41.8 micrograms per grams, organic carbon normalized (ug/goc), with a 95 percent CI of 8.29 to 214 ug/goc. To convert these values to site-specific sediment criteria on a dry-weight basis, they can be multiplied by the TOC fraction in the sediment. Assuming a TOC of 5 percent for the lower harbor/bay, the acceptable sediment PCB concentration range using the EP methodology is 2.1 micrograms per gram (ug/g) with the 95 percent CI 0.4 to 11 ug/g PCB. A significant portion of the lower harbor/bay has sediment PCB concentrations in excess of this range. Subsection 2.2.3 describes the PCB distribution in the study area and Figure 2-7 illustrates this information. These acceptable concentrations are derived using the AWQC for PCBs which, in turn, are based on a residue concentration in biota following bioconcentration of these compounds. Water quality guidelines based strictly on the chronic toxicity effects of PCBs do not exist.

3.3.2 Apparent Effects Threshold

The Apparent Effects Threshold (AET) approach uses field data (e.g., chemical concentrations in sediment) and at least one biological indicator of injury (e.g., sediment bioassays, altered benthic infaunal abundance, bioconcentration, and histopathology) to determine the concentration of a given contaminant above which statistically significant biological effects would be expected (Field and Dexter, 1988). The AET requires a large data base on contaminant toxicity and site-specific information. One potential limitation of the AET methodology is that the results can be strongly influenced by the presence of unmeasured, covarying toxic contaminants (Field and Dexter, 1988). The following AET values for total PCBs values were developed for Puget Sound, Washington:

	Amphipod	Oyster	Benthic Infauna
AET ug/goc	190	>46	65
AET ug/g (dry weight)	3.1	1.1	1.0

These values are presented for illustrative purposes. The site-specific nature of the AET methodology limits the application of these values to New Bedford Harbor.

3.3.3 Screening Level Concentrations

The Screening Level Concentration (SLC) approach compares field data on sediment contaminant concentrations to the presence or absence of benthic species. The SLC is an estimate of the highest concentration of a particular contaminant in sediment that can be tolerated by approximately 95 percent of benthic infauna (Field and Dexter, 1988). A cumulative frequency distribution of a specific species is plotted against the sediment contaminant concentration, and the 90th percentile is termed the Species

Screening Level Concentration (SSLC). These SSLC levels, in turn, are plotted for a large number of species as a frequency distribution; the SLC is defined as the concentration above which 95 percent of these levels are found. The saltwater SLC value for total PCBs is 3.66 ug/goc (range zero to 4.58). Assuming 5 percent TOC in the lower harbor/bay, the SLC for New Bedford Harbor is 0.2 (range zero to 0.2). As discussed in Subsection 2.2.3, a significant portion of the study area exceeds this value.

In general, the SLC values have proven to be very conservative in comparison to values derived using other approaches. As with the AET, the SLC requires a large data base with a broad range of toxicant concentrations to define the influence of a particular contaminant. The major limitation of this approach is that the presence of a species at a site does not necessarily imply lack of biological effect (Field and Dexter, 1988).

3.3.4 Sediment Quality Triad

The Sediment Quality Triad (SQT) uses sediment chemistry, toxicity, and biological effects to determine sediment concentrations that discriminate conditions of minimal, uncertain, and major biological effects. It is recommended that site-specific criteria be developed for various locations within a study area, based on the local chemical and biological data. This procedure was used to develop sediment quality levels for total PCBs in Puget Sound, Washington. These values were reported as follows:

Criteria Description	Criteria
No or minimal effects	≤0.1 ug/g (dw)
Severe effects	≥0.8 ug/g (dw)

The triad approach requires a definition of "minimal" and "severe" biological effects to establish criteria. These definitions are subjective depending on the particular objectives of the site-specific ecological assessment. The site-specific nature of these values limits their application to New Bedford Harbor. However, they do provide an indication of the potential risks associated with PCB exposure. Areas in the lower harbor/bay exceed by over an order of magnitude these criteria values, suggesting the potential for adverse ecological effects.

3.3.5 Summary

A review of four general approaches to evaluating ecological risk (i.e., EP, SLC, AET, and SQT) was undertaken to support conclusions of the baseline risk assessment and to assist in the development of PCB TCLs for New Bedford Harbor. Certain limitations exist that preclude a direct comparison between the developed criteria values and contaminant concentrations in New Bedford Harbor. However, these methodologies can be used to provide a qualitative evaluation of the potential ecological risks at this site.

The sediment PCB concentrations considered to be protective of aquatic resources identified using the four approaches described above range from approximately 0.01 to 1.0 ppm PCB. These values are derived from a review of published information on the bioaccumulation and toxicological effects of PCBs and on site-specific toxicity information. A comparison of this range of values to the current extent of PCB contamination in sediments in the estuary and the lower harbor/bay shows a significant area in excess of the upper concentration of 1 ppm (see Subsection 2.2.3 and Figure 2-7). Although it is recognized that the range 0.01 to 1.0 ppm has a substantial but undefined uncertainty, the magnitude and extent to which this range is exceeded support the conclusions of the baseline risk assessment that the presence of PCBs may cause adverse ecological effects are likely.

4.0 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES, APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS, AND GENERAL RESPONSE ACTIONS

Remedial action objectives serve as guidelines in the development of alternatives for remediation. The remedial action objectives specify the contaminants and media of interest, exposure pathways, and preliminary remediation goals.

The site-specific ARARs and the remedial action objectives for the estuary and lower harbor/bay areas are discussed in Subsections 4.2 and 4.3, respectively. These objectives are subsequently used to develop general response actions (see Subsection 4.4) that will formulate the basis for the selection of technologies (see Section 5.0), and the development and evaluation of alternatives for remediation of the estuary and lower harbor/bay areas (see Sections 6.0 and 7.0).

4.1 INTRODUCTION

Remedial actions, as defined by 300.5 of the National Contingency Plan (NCP), are those responses to releases that are consistent with a permanent remedy to protect against or minimize release of hazardous substances, pollutants, or contaminants so they do not migrate to cause substantial danger to current or future public health and welfare or the environment.

In formulating a remedy, CERCLA requires EPA to emphasize risk reduction through destruction or treatment of hazardous waste. Section 121 of SARA establishes a statutory preference for remedies that permanently and significantly reduce the mobility, toxicity, or volume of hazardous waste over remedies that do not use such treatment. Section 121 also requires EPA to select a remedy that is protective of public health and the environment, is cost-effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. Furthermore, Section 121 requires that, upon completion, remedies must attain ARARs unless specified waivers are granted.

Section 300.430 of the NCP, in conjunction with EPA guidance on conducting FSs, sets forth the remedial alternative development and evaluation process (EPA, 1988). This process consists of the following steps:

- o Identify the nature and extent of contamination and threat presented by the release (300.430[d][2]).
- o Identify general response objectives for site remediation (300.430[e][2][i]).

- Identify and evaluate remedial technologies potentially applicable to wastes and site conditions (300.430[e][2][ii]).

- Develop alternatives to achieve site-specific response objectives (300.430[e][2][iii]).

- Conduct initial screening of alternatives (300.430[e][7]).

- Conduct detailed analysis of alternatives (300.430[e][9]).

Figure 4-1 is an overview of the FS process for the New Bedford Harbor Superfund site.

As an initial step, both CERCLA and the NCP require identification of the nature and extent of site contamination. The nature and distribution of contamination and the threat posed by the release of contaminants from the estuary and lower harbor/bay areas are discussed in Sections 2.0 and 3.0. Beyond initial site characterization, Section 121 of SARA retains the basic framework for the remedial alternatives development and remedy selection process enacted through NCP; however, each phase must be modified to reflect the provisions of SARA.

4.2 SITE-SPECIFIC ARARS

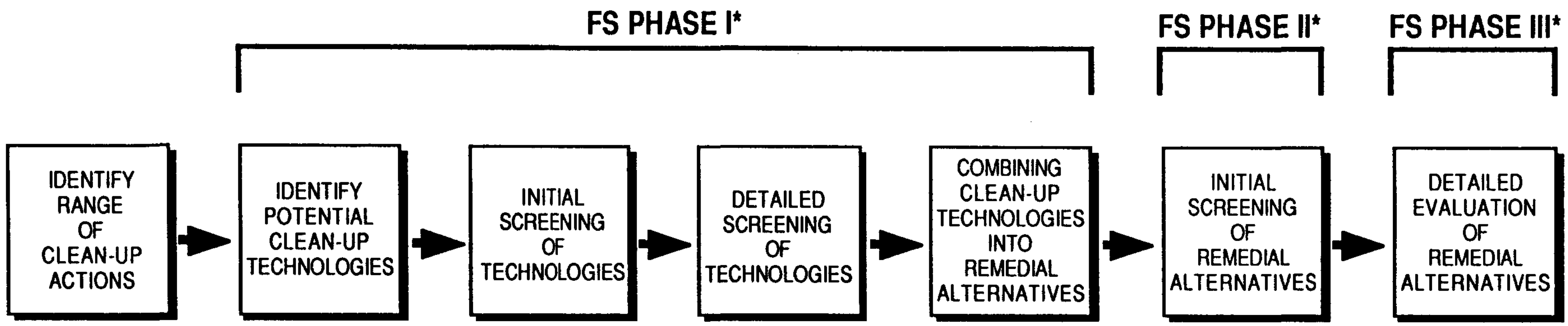
Section 121(d) of SARA and the NCP require that CERCLA remedial actions comply with all federal ARARs. State requirements must also be attained under Section 121 (d)(2)(c) of SARA, if they are legally enforceable and consistently enforced statewide. ARARs are used to determine the appropriate extent of site cleanup, identify and formulate remedial action alternatives, and govern the implementation and operation of the selected action. According to SARA, requirements may be waived by EPA under the following six specific conditions, provided protection of public health and the environment is still assured:

- The selected remedial action is an interim remedy.

- Compliance with such requirements will result in greater risk to public health and the environment than alternative options.

- Compliance with such requirements is technically impracticable from an engineering perspective.

- The selected remedial action will provide a standard of performance equivalent to other approaches required under applicable regulations.



* EPA OSWER DIRECTIVE OCTOBER, 1988: GUIDANCE FOR CONDUCTING REMEDIAL INVESTIGATION AND FEASIBILITY STUDIES UNDER CERCLA

FIGURE 4-1
OVERVIEW OF THE FS PROCESS
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

- The requirement is a state requirement that has been inconsistently applied.

- Attainment of the ARAR would entail extremely high costs relative to the added degree of reduction of risk afforded by the standard (i.e., fund balancing).

In this subsection, the approach to ARARs for the estuary and lower harbor/bay FS is discussed, and potential ARARs are identified.

4.2.1 Definition of ARARs

To consider ARARs and, more importantly, to incorporate consideration of ARARs in the FS and remedial response processes, the NCP and SARA defined both applicable requirements and relevant and appropriate requirements as follows.

Applicable Requirements. Applicable requirements are those federal and state requirements that would be legally applicable, either directly or as incorporated by a federally authorized state program, if response actions were not taken pursuant to Section 104 or 106 of CERCLA.

Requirements that are applicable to and have jurisdiction over given situations are considered "applicable requirements." An example of an applicable requirement would be MCLs for a site that exhibits groundwater contamination entering a public water supply.

Relevant and Appropriate Requirements. Relevant and appropriate requirements are those federal and state requirements that, while not legally "applicable," can be applied if the decision-maker's best professional judgment determines that site circumstances are sufficiently similar to those situations that are jurisdictionally covered, and use of the requirement makes good sense. During the FS process, relevant and appropriate requirements are intended to have the same weight and consideration as applicable requirements.

The term "relevant" was included so that a requirement initially screened as nonapplicable because of jurisdictional restrictions would be reconsidered and, if appropriate, included as an ARAR for the site. For example, MCLs would be nonapplicable, but relevant and appropriate for a site that exhibited groundwater contamination in a potential (as opposed to an actual) drinking water source.

Other Requirements to be Considered. A third category of requirements to be considered is federal and state nonregulatory requirements (e.g., guidance documents or criteria).

Nonpromulgated advisories or guidance documents do not have the status of ARARs. However, where there are no specific ARARs for a chemical or situation, or where such ARARs are not sufficient to be protective, guidance or advisories should be identified and used to ensure that a remedy is protective.

4.2.2 Development of ARARs

Under the description of ARARs set forth in the NCP and SARA, many federal and state environmental requirements must be considered. These requirements include ARARs that are:

- o chemical-specific (i.e., govern the extent of site cleanup)
- o location-specific (i.e., pertain to existing site features)
- o action-specific (i.e., pertain to proposed site remedies and govern implementation of the selected site remedy)

A separate document entitled, "Regulation Assessment for New Bedford Harbor" was published for the New Bedford Harbor site that has identified the potential chemical-, location-, and action-specific ARARs (E.C. Jordan Co./Ebasco, 1990b). This document identifies both federal and state ARARs and summarizes the procedural and technical requirements of these regulations. ARARs pertinent to the estuary and lower harbor/bay areas are summarized in the following subsection.

4.2.2.1 Chemical-specific ARARs

Chemical-specific ARARs govern the extent of site cleanup and provide either actual clean-up levels or a basis for calculating such levels. For example, surface water criteria and standards, as well as air standards, provide necessary clean-up goals for the estuary and lower harbor/bay FS.

Chemical-specific ARARs are also used to indicate acceptable levels of discharge to determine treatment and disposal requirements, and to assess the effectiveness of remedial alternatives. Table 4-1 lists and summarizes potential chemical-specific ARARs. Chemical-specific ARARs apply to every alternative. Descriptions of chemical-specific ARARs for surface water and air follow.

<u>Surface Water</u>. Surface water in the estuary and lower harbor/bay is governed generally by the federal Clean Water Act (CWA) and specifically by the Massachusetts Surface Water Quality Standards (310 CMR 4.00). The federal statute has a general mandate to preserve water quality. The state develops

TABLE 4-1
POTENTIAL CHEMICAL-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

MEDIUM/AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE RI/FS
Surface Water				
Federal Regulatory Requirements	Federal Food, Drug and Cosmetic Act	Applicable	This act sets forth FDA limit of 2 ppm for PCB concentrations in commercial fish and shellfish.	This level will be used as an ultimate clean-up level to which alternatives will be evaluated.
State Regulatory Requirements	MADEP - Massachusetts Surface Water Quality Standards (310 CMR 4.00)	Applicable	MADEP surface water quality standards incorporate the federal AWQC as standards for surface waters of the state.	AWQC applicable to the Estuary and Lower Harbor/Bay area are as follows: PCBs - 10 ppb (acute effects on aquatic life) - 0.03 ppb (chronic effects on aquatic life) Cadmium - 43 ppb (acute effects) 9.9 ppb (chronic effects) Copper - 2.9 ppb (acute effects) 2.9 ppb (chronic effects) Lead - 140 ppb (acute effects) - 5.6 ppb (chronic effects)
Federal Criteria, Advisories, and Guidance	Federal Ambient Water Quality Criteria (AWQC)	Applicable	Federal AWQC are health-based criteria developed for 95 carcinogenic and noncarcinogenic compounds.	AWQC are incorporated into MADEP standards as discussed above. The PCB criterion is based on the old 5-ppm FDA standard. Clean-up targets may be modified to reflect current guidance levels, which are lower.
Air				
Federal Regulatory Requirements	CAA - National Ambient Air Quality Standards (NAAQS) - 40 CFR 40.	Relevant and Appropriate	These standards were primarily developed to regulate stack and automobile emissions.	Standards for particulate matter will be used when assessing excavation and emission controls for sediment treatments.
State Regulatory Requirements	MADEP - Air Quality, Air Pollution (310 CMR 6.00 - 8.00).	Relevant and Appropriate	These standards were primarily developed to regulate stack and automobile emissions.	Alternatives involving excavation, air, and emission controls for sediment treatments will be compared against these standards.
Federal Criteria, Advisories, and Guidance	Threshold Limit Value (TLV)	To Be Considered	These standards were issued as consensus standards for controlling air quality in workplace environments.	TLVs could be used for assessing site inhalation risks for soil removal operations.

general criteria for surface water quality and determining standards. The federal AWQC are applicable to the estuary and lower harbor because they are incorporated as Massachusetts surface water quality standards. Under these rules, the concentration of contaminants in sediments will need to be at levels that assure that water in the estuary and lower harbor/bay meets regulatory criteria.

The Federal Food, Drug, and Cosmetic Act (FFDCA) must also be considered because it sets a limit of 2 ppm of PCBs in commercial fish and shellfish.

Remedial alternatives that propose technologies that generate process water, leachate, or supernatant to be returned to the harbor will be subject to the CWA and Massachusetts Surface Water Quality Standards. Discharge waters will have to meet the standards promulgated by the state.

Air. Federal and state air regulations that establish concentration limits for particulate matter are considered chemical-specific ARARs where excavation activities, for example, may generate dust and debris. Massachusetts has set an Allowable Ambient Level (AAL) of 0.0005 micrograms per cubic meter for PCBs; however, in certain areas of the estuary and lower harbor/bay, the existing background air quality currently exceeds this AAL.

4.2.2.2 Location-specific ARARs

Location-specific ARARs govern natural site features such as wetlands and floodplains, as well as manmade features including existing landfills, disposal areas, and local historic buildings. Location-specific ARARs are generally restrictions on the concentration of hazardous substances or the conduct of activities solely because of the site's particular characteristics or location. These ARARs provide a basis for assessing existing site conditions and subsequently aid in assessing potential remedial alternatives. Table 4-2 lists and summarizes potential location-specific ARARs. For the estuary and lower harbor/bay FS, applicable location-specific ARARs will be requirements that protect wetland and floodplain areas. Some location-specific ARARs may be interpreted as action-specific ARARs, such as those requiring permits or licenses for work performed in a waterway, floodplain, or wetland. However, they are described herein to provide continuity for discussions of regulations affecting proposed remedial alternatives of the estuary and lower harbor/bay sediments. According to SARA, remedial actions undertaken entirely on-site need to comply only with substantive aspects of ARARs and not with corresponding administrative requirements (i.e., permits).

TABLE 4-2
POTENTIAL LOCATION-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

MEDIUM/AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE RI/FS
Wetlands/Floodplains Federal Regulatory Requirements	Clean Water Act (CWA) 40 CFR Part 404	Applicable	Under this requirement, no activity that adversely affects a wetland shall be permitted if a practicable alternative that has less effect is available. If there is no other practical alternative, impacts must be mitigated. Section 307, effluent standards of 1-ppb concentration of PCB, is incorporated into this section by reference. The 1-ppb effluent discharge standard is to be considered for guidance levels.	During the identification, screening, and evaluation of alternatives, the effects on wetlands are evaluated. Effluent levels will be used as guidance levels to which alternatives will be evaluated.
	RCRA Location Standards (40 CFR 264.18)	Relevant and Appropriate	This regulation outlines the requirements for constructing a RCRA facility on a 100-year floodplain.	A facility located on a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood, unless waste may be removed safely before floodwater can reach the facility or no adverse effects on public health and the environment would result if washout occurred.
	National Environmental Policy Act (42 U.S.C. 4321; 40 CFR Part 6)	Applicable	Sets forth EPA policy for carrying out the provisions of the Wetlands Executive Order (EO 11990) and Floodplain Executive Order (EO11988).	This requirement will be considered during the development of alternatives.
State Regulatory Requirements	MADEP - Wetlands Protection (310 CMR 10.00)	Applicable	These regulations are promulgated under Wetlands Protection Laws, which regulate dredging, filling, altering, or polluting inland wetlands. Work within 100 feet of a wetland is regulated under this requirement. The requirement also defines wetlands based on vegetation type and requires that effects on wetlands be mitigated.	If alternatives involve removing, filling, dredging, or altering a MADEP-defined wetland, a Notice of Intent must be filed with MADEP. If work is conducted within 100 feet of a wetland, a request for a Determination Applicability must be filed. Any person who files a Notice of Intent must demonstrate that the area is not significant to the wetland or that the proposed work will contribute to the protection of the wetland.
Federal Nonregulatory Requirements to be Considered	Wetlands Executive Order (EO 11990)	To be Considered	Under this regulation, federal agencies are required to minimize the destruction loss or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands.	Remedial alternatives that involve construction must include all practicable means of minimizing harm to wetlands. Wetlands protection considerations must be incorporated into the planning and decision-making about remedial alternatives.

TABLE 4-2
(continued)
POTENTIAL LOCATION-SPECIFIC ARARS AND CRITERIA, ADVISORIES, AND GUIDANCE

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

MEDIUM/AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE RI/FS
Wetlands/Floodplains Federal Nonregulatory Requirements to be Considered (continued)	Floodplains Executive Order (EO 11988)	To Be Considered	Federal agencies are required to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial values of floodplains.	The potential effects of any action must be evaluated to ensure that the planning and decision-making reflect consideration of flood hazards and floodplain management, including restoration and preservation of natural undeveloped floodplains.

Wetlands, Waterways, and Floodplains. For actions involving construction of facilities in wetlands or alterations of wetland property, National Environmental Protection Act (NEPA) regulations (40 CFR Part 6) are applicable. NEPA requires that federal agencies include in decision-making processes appropriate and careful consideration of all environmental effects of the proposed actions, and restore and enhance environmental quality as much as possible. In general, compliance with SARA and the NCP assures compliance with NEPA. Appendix A of 40 CFR Part 6 specifically sets forth policy and guidance for carrying out provisions of the Wetlands Executive Order (EO 11990) and the Floodplain Executive Order (EO 11988). An alternative located in a wetland or floodplain may not be selected unless it is determined that no practicable alternative exists outside the wetland. If no practicable alternative exists outside the resource area, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values.

Section 404 of the CWA regulates the discharge of dredged and fill materials to waters of the U.S. Filling wetlands would be considered a discharge of fill material to waters of the U.S. Procedures for complying with permit conditions are contained in 33 CFR Part 323. Guidelines for Specification of Disposal Sites for Dredged or Fill Material at 40 CFR Part 230, promulgated under CWA Section 404(b)(1), maintain that no discharge of dredge or fill material will be permitted if there is a practicable alternative that would have less adverse impact on the aquatic system. Because the estuary and lower harbor/bay sediments are contaminated, no practicable alternative is believed to exist that would remediate the sediment without disturbing the aquatic system.

In addition, Section 10 of the River and Harbor Act of 1899 requires authorization from the Secretary of the Army, acting through USACE, for the construction of any structure in or over any "navigable water of the U.S.," the excavation from or deposition of material in such waters, or any obstruction or alternation in such waters.

At the state level, wetlands and land subject to flooding are protected under the Massachusetts Wetlands Protection Act and Wetlands Regulations at 310 CMR 10.00. Anyone proposing an activity within an area subject to protection under the Wetlands Protection Act should file a Notice of Intent (NOI) with the Municipal Conservation Commission and obtain a final Order of Condition before proceeding with the activity. The Wetlands Protection Act also has jurisdiction over a 100-foot buffer zone from the resource area. Activities proposed within the 100-foot buffer zone should either file a Determination of Applicability or an NOI with the municipal conservation commission. Activities such as excavation of a riverbed would require the filing of an NOI under the Wetlands Protection Act.

The Massachusetts Waterways Act (Massachusetts General Law, Chapter 91) and regulations at 310 CMR 9.00 require that any work in or over any tidelands, river, or stream (with respect to which public funds have been expended), or great pond, or any outlet thereof, obtain a license from the Massachusetts Department of Environmental Protection (MADEP). Pursuant to Section 212(e) of SARA, permit requirements under the Chapter 91 Waterways License Agreement are waived for activities occurring on-site; however, compliance with the substantive standards must be achieved.

For activities that include dredging or filling of waters, or wetlands that require a MADEP Wetlands Order of Conditions, a Chapter 91 Waterways License, a USACE permit, or any major permit issued by EPA (e.g., CWA National Pollutant Discharge Elimination System permit), a Massachusetts Department of Water Pollution Control Water Quality Certification pursuant to 314 CMR 9.00 is applicable.

Regulations entitled "Certification for Dredging" and "Dredged Materials Disposal and Filling in Waters" are intended to encompass dredging projects in waters or wetland areas of the state that are also subject to the jurisdiction of either a federal agency under CWA (Section 401) or the Massachusetts Wetlands Act or Waterway Act. The regulations specify sampling methods and a classification system for dredge or fill material. Application forms may be required to be prepared and submitted for certification that the project will attain or maintain Massachusetts Water Quality Standards and minimize adverse impact to the environment.

The Environmental Affairs Coastal Zone Management (CZM) Program (301 CMR 20.00-22.00) established the Massachusetts CZM program under the federal Coastal Zone Management Act (15 CFR 930). These regulations are promulgated to establish CZM policies and to ensure that they are administered in a coordinated and consistent manner.

The federal act requires that any federal agency proposing to do work in a state's coastal zone must submit a plan outlining how all work to be performed is consistent with the state program. The Massachusetts CZM program policies are implemented with other state agencies (e.g., MADEP) through the standards and criteria of these agencies' regulations. Compliance with the Massachusetts CZM program will be met through attainment of MADEP location- and action-specific ARARs.

4.2.2.3 Action-specific ARARs

Action-specific ARARs are usually technology- or activity-based limitations that control actions at CERCLA sites. After remedial alternatives are developed, action-specific ARARs pertaining to proposed site remedies provide a basis for assessing the feasibility and effectiveness of the remedies. For example, these action-specific ARARs may include hazardous waste transportation and handling requirements, air and water emissions standards, and the TSCA and Resource Conservation and Recovery Act (RCRA) landfilling and treatment requirements. Potential action-specific ARARs, listed and summarized in Table 4-3, are discussed in the detailed evaluation of alternatives (see Section 7.0).

The Occupational Safety and Health Administration (OSHA) (29 CFR 19190, 1926) and Massachusetts "Right-to-Know" regulations are action-specific ARARs that apply to each alternative. On the federal level, OSHA is responsible for worker safety at CERCLA sites. These regulations set standards for exposure limits, safety training, protective equipment, and employer responsibility. At the state level, community and worker health and safety is protected by the Right-to-Know regulations promulgated by three agencies: MADEP (310 CMR 33.00), Department of Labor and Industry (454 CMR 21.00), and Department of Public Health (105 CMR 670.00). These rules require hazardous substance disclosure and are applicable to activities conducted during remediation of the estuary and the lower harbor/bay.

4.3 DEVELOPMENT OF TARGET CLEAN-UP LEVELS

TCLs are developed as part of the remedial action objectives. These levels identify contaminant concentrations in each medium of concern considered protective of public health and the environment. TCLs are either based on ARARs when available (i.e., surface water TCLs are set at AWQC) or developed based on exposure and risk considerations.

Public health TCLs were developed based on EPA guidelines and MCP requirements. EPA states that the total incremental carcinogenic risk for an individual resulting from exposure at a hazardous waste site should be between 10^{-4} and 10^{-6}. Therefore, remedial alternatives should reduce total potential carcinogenic risks to levels less than 10^{-4} (EPA, 1988). The MCP uses a total site carcinogenic risk level of 10^{-5} to evaluate the need for remediation at hazardous waste sites. For New Bedford Harbor, a risk level of 10^{-5} (one excess cancer event per 100,000 exposures) was selected to develop chemical-specific target levels for each medium of concern. This level is consistent with the MCP and the mid-point of the EPA target range. A risk level of 10^{-5} is considered to provide an adequate level of protection to public health.

For noncarcinogenic compounds, EPA uses an HI value of 1.0 to determine remedial actions at Superfund sites (EPA, 1988). The MCP uses an HI of 0.2 to evaluate noncarcinogenic risks. As

TABLE 4-3
POTENTIAL ACTION-SPECIFIC ARARS

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

ARARS	REQUIREMENT SYNOPSIS	ACTION TO BE TAKEN TO ATTAIN ARARS
RCRA - General Facility Standards (40 CFR 264.10 - 264.18)	General facility requirements outline general waste analysis, security measures, inspections, and training requirements.	Any facilities will be constructed, fenced, posted, and operated in accordance with this requirement. All workers will be properly trained. Process wastes will be evaluated for the characteristics of hazardous wastes to assess further landfilling requirements.
RCRA - Preparedness and Prevention (40 CFR 264.30 - 264.31)	This regulation outlines requirements for safety equipment and spill control.	Safety and communication equipment will be installed at the site; local authorities will be familiarized with site operations.
RCRA - Contingency Plan and Emergency Procedures (40 CFR 264.50 - 264.56)	This regulation outlines the requirements for emergency procedures to be used following explosions, fires, etc.	Plans will be developed and implemented during site work including installation of monitoring wells, and implementation of site remedies. Copies of the plans will be kept on-site.
RCRA - Releases from Solid Waste Management Units (40 CFR 264.90 - 264.109)	This regulation details requirements for a groundwater monitoring program to be installed at the site.	A groundwater monitoring program is a component of all alternatives. RCRA regulations will be utilized as guidance during development of this program.
RCRA - Closure and Post-closure (40 CFR 264.110 - 264.120)	This regulation details specific requirements for closure and post-closure of hazardous waste facilities.	Those parts of the regulation concerned with long-term monitoring and maintenance of the site will be incorporated into the design.
RCRA - Surface Impoundments Items (40 CFR 264.220 - 264.249)	This regulation details the design, construction, operation, monitoring, inspection, and contingency plans for a RCRA surface impoundment. Also provides three closure options for CERCLA sites; clean closure, containment closure, and alternate closure.	To comply with clean closure, owner must remove or decontaminate all waste. To comply with containment closure, the owner must eliminate free liquid, stabilize remaining waste, and cover impoundment with a cover that complies with the regulation. Integrity of cover must be maintained, groundwater system monitored, and runoff controlled. To comply with alternate closure, all pathways of exposure to contaminants must be eliminated and long-term monitoring provided.
RCRA - Waste Piles (40 CFR 264.250 - 264.269)	Details procedures, operating requirements, and closure and post-closure options for waste piles. If removal or decontamination of all contaminated subsoils is not possible, closure and post-closure requirements for landfills must be attained.	According to RCRA, waste piles used for treatment or storage of non-containerized accumulation of solid, non-flowing hazardous waste may comply with either the waste pile or landfill requirements. The temporary storage of solid waste on-site, therefore, must comply with one or the other subpart.
RCRA - Landfills (40 CFR 264.300 - 264.339)	This regulation details the design, operation, monitoring, inspection, recordkeeping, closure, and permit requirements for a RCRA landfill.	Disposal of contaminated materials from the harbor would be to a RCRA-permitted facility that complies with RCRA landfill regulations, including closure and post-closure. On-site disposal would include a RCRA-designed cap.

TABLE 4-3
(continued)
POTENTIAL ACTION-SPECIFIC ARARS

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

ARARS	REQUIREMENT SYNOPSIS	ACTION TO BE TAKEN TO ATTAIN ARARs
RCRA - Incinerators (40 CFR 264.340 - 264.599)	This regulation specifies the performance standards, operating requirements, monitoring, inspection, and closure guidelines of any incinerator burning hazardous waste.	On-site thermal treatment must comply with the appropriate requirements specified in this subpart of RCRA.
RCRA - Miscellaneous Units (40 CFR 264.600 - 264.999)	These standards are applicable to miscellaneous units not previously defined under existing RCRA regulations for treatment, storage, and disposal units.	Units not previously defined under RCRA must comply with these requirements.
TSCA Disposal Requirements (40 CFR Part 761.60)	PCBs at concentrations greater than 50 ppm, but less than 500 ppm, must be disposed of either in an incinerator, or in a chemical waste landfill, or by another technology capable of providing equal treatment. PCBs at concentrations greater than 500 ppm must be disposed of in an incinerator or treated by an alternate technology capable of equal treatment or disposed of in a chemical waste landfill. Dredged materials with PCB concentrations greater than 50 ppm may be disposed of by alternative methods which are protective of public health and the environment, if shown that incineration or disposal in a chemical waste landfill is not reasonable or appropriate.	PCB treatment must comply with these regulations during remedial action.
OSHA - General Industry Standards (29 CFR Part 1910)	These regulations specify the 8-hour time-weighted average concentration for various organic compounds. Training requirements for workers at hazardous waste operations are specified in 29 CFR 9910.120.	Proper respiratory equipment will be worn if it is impossible to maintain the work atmosphere below the specified concentrations. Workers performing remedial activities would be required to have completed specified training requirements.
OSHA - Safety and Health Standards (29 CFR Part 1926)	This regulation specifies the type of safety equipment and procedures to be followed during site remediation.	All appropriate safety equipment will be on-site. In addition, safety procedures will be followed during on-site activities.
OSHA - Recordkeeping, Reporting, and Related Regulations (29 CFR 1904)	This regulation outlines the recordkeeping and reporting requirements for an employer under OSHA.	These requirements apply to all site contractors and subcontractors and must be followed during all site work.
CWA - 40 CFR Part 403	This regulation specifies pretreatment standards for discharges to a publicly owned treatment works (POTW).	If a leachate collection system is installed and the discharge is sent to a POTW, the POTW must have an approved pretreatment program. The collected leachate runoff must be in compliance with the approved program. Prior to discharging, a report must be submitted containing identifying information, list of approved permits, description of operations, flow measurements, measurement of pollutants, certification by a qualified professional, and a compliance schedule.

TABLE 4-3
(continued)
POTENTIAL ACTION-SPECIFIC ARARS

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

ARARS	REQUIREMENT SYNOPSIS	ACTION TO BE TAKEN TO ATTAIN ARARS
MADEP - Administration of Waterway License (310 CMR 9.00)	The rules were promulgated to establish procedures and criteria to protect public rights of fishing, fowling, and navigation in the marine and tidelands of the Commonwealth.	Design of capping and cover systems must be approved prior to construction. Dredging of sediment, and remedial activities conducted in tidal and saltwater areas need to comply with standards set forth in these rules.
EOEA - Coastal Zone Management (CZM) Program (301 CMR 20.00 - 22.00)	These regulations are promulgated to establish regulatory and non-regulatory CZM policies that include: #1 - protection of ecologically significant resource areas #3 - attainment of national water quality goals #5 - promote minimizing adverse effects from dredging and disposal of dredged material #10 - development in coastal zone areas complies with state and federal air and water pollution, and inland wetlands regulations	These requirements will be attained through compliance with MADEP regulations: 310 CMR 6.00 Ambient Air Quality Standards 310 CMR 7.00 Air Pollution Control 310 CMR 9.00 Waterways Licenses 310 CMR 10.00 Wetlands Protection 310 CMR 19.00 Solid Waste Disposal 310 CMR 30.00 Hazardous Waste 314 CMR 9.00 Dredging
DPH - Right to Know (105 CMR 670)	This regulation establishes the Massachusetts Substance List. The goal of this regulation is to protect public health by providing information concerning hazardous substances.	This regulation will be attained during implementation of the remedial alternative by providing all workers with hazardous substance information.
MADEP - Disposal of Solid Waste by Sanitary Landfill (310 CMR 19.00)	This regulation establishes rules and requirements for solid waste disposal facilities.	Landfilling of screened, non-hazardous material will comply with this regulation.
MADEP - Right to Know (310 CMR 33.00)	This regulation establishes rules and requirements for the dissemination of information related to substances hazardous to the public.	This regulation will be attained during the implementation of the remedial alternative by providing the public with hazardous substance information.
DOI - Right to Know (441 CMR 21.00)	This regulation establishes requirements for worker "right to know."	This regulation will be attained during implementation of the remedial alternative by providing all workers with hazardous substance information.

TABLE 4-3
(continued)
POTENTIAL ACTION-SPECIFIC ARARS

ESTUARY AND LOWER HARBOR/BAY FEASIBILITY STUDY
NEW BEDFORD HARBOR, MASSACHUSETTS

ARARS	REQUIREMENT SYNOPSIS	ACTION TO BE TAKEN TO ATTAIN ARARS
Regulations on Disposal Site Determinations Under the Water Act (40 CFR 231)	These regulations apply to all existing, proposed, or potential disposal sites for discharges of dredged or fill material into U.S. waters, which include wetlands.	The dredged or fill material should not be discharged unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact on the wetlands.
DOT Rules for Transportation of Hazardous Materials (49 CFR Parts 107, 171.1-171.5)	This regulation outlines procedures for the packaging, labeling, manifesting, and transporting of hazardous materials.	Contaminated materials will be packaged, manifested, and transported to a licensed off-site disposal facility in compliance with these regulations.
MADEP - Hazardous Waste Regulations, Phases I and II. (310 CMR 30.000, MGL Ch. ZIC)	This regulation provides a comprehensive program for the handling, storage, and recordkeeping at hazardous waste facilities. They supplement RCRA regulations.	Because these requirements supplement RCRA hazardous waste regulations, they must also be considered at New Bedford Harbor.
MADEP - Massachusetts Contingency Plan (310 CMR 40.000)	These regulations provide the framework for the Commonwealth of Massachusetts to regulate hazardous waste activities in the state.	During remedial design, these regulations will be compared to the corresponding federal CERCLA regulations, and the more stringent requirements will be applicable.
MADEP - Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Dischargers (314 CMR 12.00)	This regulation outlines the operation and maintenance requirements applicable to operators of wastewater treatment facilities. These rules require treatment to meet standards set forth in 314 CMR 3.00 and 5.00.	Operation of any treatment facilities on-site will be in accordance with the procedures and rules in this regulation.
MADEP - Massachusetts Surface Water Discharge Permit Program (314 CMR 1.00-7.00)	This section outlines the requirements for obtaining a National Pollutant Discharge Elimination System (NPDES) permit in Massachusetts.	Pollutant discharges to surface water must comply with NPDES permit requirements. Permit conditions and standards for different classes of water are specified.
MADEP - Supplemental Requirements for Hazardous Waste Management Facilities (314 CMR 8.00)	This regulation outlines the additional requirements that must be satisfied in order for a RCRA facility to comply with the NPDES regulations. These regulations are applicable to a water treatment unit; a surface impoundment that treats influent wastewater; and a POTW that generates, accumulates, and treats hazardous waste.	All owners and operators of RCRA facilities shall comply with the management standards of 310 CMR 30.500, the technical standards of 310 CMR 30.600, the location standards of 310 CMR 30.700, the financial responsibility requirements of 310 CMR 30.900, and in the case of POTWs, the standards for generators in 310 CRM 30.300.
Certification for Dredged Material Disposal and Filling in Waters (314 CMR 9.00)	This regulation is promulgated to establish procedures, criteria, and standards for the water quality certification of dredging and dredged material disposal.	Applications for proposed dredging/fill work need to be submitted and approved before work commences. Three categories have been established for dredge or fill material based on the chemical constituents. Approved methods for dredging, handling, and disposal options for the three categories must be met.

discussed, the HI is the ratio of the expected dose of each contaminant to the most applicable health-based standard or criteria value. An HI of 1.0 implies that the incurred exposure dose does not exceed an exposure dose considered protective of public health.

For the New Bedford Harbor site, public health target levels are developed for the contaminants of concern that show a baseline carcinogenic risk exceeding 10^{-5} or noncarcinogenic risk greater than a total HI of 1.0 and 0.2. Because there are no state or federal guidelines for developing ecological TCLs, these values were derived based on the risk assessment methodologies discussed in Section 3.0.

4.3.1 Public Health Target Clean-up Levels

The public health risks associated with contaminant exposure in the estuary and the lower harbor/bay result from direct contact and/or incidental ingestion of PCB- and lead-contaminated shoreline sediment and ingestion of PCB-contaminated biota. PCB contaminant concentrations detected in biota from this area exceed the current FDA tolerance level of 2 ppm PCB. Exposures to metals and PCB concentrations in shoreline sediment are associated with both carcinogenic and noncarcinogenic risks within and in excess of both EPA and Massachusetts target risk ranges (see Section 3.0).

4.3.1.1 Public Health Target Clean-up Levels

Because there are no sediment-specific ARARs to use in developing clean-up levels, site-specific TCLs were developed based on the protection of public health. The population considered to be at greatest risk from contaminant exposure in the estuary, lower harbor, and bay is young children (through age 6). This population was identified based on land use and assumed activities of various age-class populations. Recreational land use in this area, in particular the state beaches, suggests that young children may have repetitive exposure to shoreline sediment. Therefore, to provide an adequate level of protection, TCLs for this study area were developed to be protective of assumed exposures by a child.

Two sets of sediment TCLs were developed: the first based on achieving the MCP criteria (total site incremental cancer risk of 10^{-5} and noncarcinogenic HI of 0.2); the second based on EPA's target risk range of 10^{-4} to 10^{-6} incremental carcinogenic risk and a noncarcinogenic HI of 1.0). Most of the exposure assumptions used in the baseline risk assessment for the probable exposure scenario were used to develop these TCLs, including the following:

- o 10-kg child (through age 6)

- o 20 exposures per year
- o five-year exposure duration
- o direct contact with 3.4 grams of sediment
- o incidental ingestion of 0.1 gram of sediment
- o 7 percent toxicokinetic factor (TKF) for PCBs; 0.1 percent for metals (dermal exposure)
- o 100 percent TKF for PCBs and metals (oral exposure)

When the original exposure assumptions were developed by the REM III team in 1986, there were no standard exposure parameters developed for the ingestion of sediment; a value of 500 milligrams (mg) was assumed to provide a conservative estimate of potential exposure. Since 1986, EPA has proposed the use of 100 mg as the average amount of soil ingested per exposure event. EPA Region I and MADEP also recommended the use of this value in assessing the incidental ingestion of soil. Because no value specific to the ingestion of sediment has been proposed, the use of 100 mg sediment has been adopted. The TCLs established using these exposure parameters are presented in Table 4-4.

4.3.1.2 Public Health Target Clean-up Levels for Biota

The current FDA tolerance level for residues of PCBs in the edible portion of fish and shellfish is 2 ppm. This concentration is established by the FDA to protect public health; however, this value is also based on technical and economic considerations and, therefore, may not be the most appropriate TCL for this site. There is no FDA tolerance level for lead concentrations in biota.

Site-specific residue levels of PCB and lead in biota were developed based on the potential exposure by an adult (i.e., 15 to 70 years). This age class was considered most likely to ingest biota on a regular basis and, therefore, was considered to be at greatest risk. Two sets of TCLs were developed based on MADEP and EPA criteria (see Subsection 4.3.1). The same exposure assumptions used in the baseline risk assessment for the probable exposure scenario were the basis of these TCLs, including the following:

- o 70-kg adult
- o 12 exposures per year (one fish meal per month)
- o 55-year exposure duration (ages 15 through 70)

TABLE 4-4
PUBLIC HEALTH TARGET CLEAN-UP LEVELS FOR SEDIMENT

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

	HAZARD INDEX	HAZARD INDEX	INCREMENTAL CANCER RISK
	0.2[a]	1[b]	10^{-5}[c]
PCBs	15 mg/kg	75 mg/kg	10 mg/kg
Cadmium	60 mg/kg	300 mg/kg	NA
Copper	4,300 mg/kg	22,000 mg/kg	NA
Lead	15 mg/kg	80 mg/kg	NA

NOTES:

[a] MADEP criteria for total site noncarcinogenic risk

[b] EPA criteria for noncarcinogenic risk

[c] MADEP criteria for total site carcinogenic risk; midpoint of EPA target risk range (10^{-6} to 10^{-4})

NA = Not Applicable

mg/kg = milligrams per kilogram

MADEP = Massachusetts Department of Environmental Protection

EPA = U.S. Environmental Protection Agency

PCB = polychlorinated biphenyls

- 227 grams of fish ingested per exposure (equivalent to 8 ounces)
- 100 percent TKF for PCBs and lead

The residue levels for PCBs and lead in the edible portion of biota are presented in Table 4-5.

4.3.2 Ecological Target Clean-up Levels

The ecological risks associated with contaminant exposure in the lower harbor/bay result from direct contact exposure to metals- and PCB-contaminated sediment and PCB-contaminated surface water. Because PCBs are lipophillic compounds, they tend to bioaccumulate within a food chain; therefore, elevated body burdens of these compounds may occur in higher trophic-level organisms. Concentrations of PCBs in the surface water of the lower harbor/bay exceed the chronic AWQC, and exposure to PCB and metals concentrations in sediments was associated with possible adverse ecological effects.

TCLs for PCBs in water and PCBs and metals in sediment were developed based on achieving an acceptable residual contaminant concentration in these media. The assumptions and methodologies used to derive these TCLs are discussed in the following subsection.

4.3.2.1 Ecological Target Clean-up Levels for Surface Water

TCLs for contaminants in surface water can be set at their respective chronic AWQC. These criteria were established by EPA and are set at levels considered protective of aquatic receptors and/or their uses. AWQC are considered ARARs at this site. For the contaminants of concern at New Bedford Harbor, the TCLs are as follows:

Contaminant	Chronic AWQC
PCBs	0.003 ug/L
Cadmium	9.3 ug/L
Copper	2.9 ug/L
Lead	5.6 ug/L

.003 ppb

PCB and copper concentrations in surface water in the estuary were detected in excess of their respective criteria. However, only PCB concentrations in surface water in the lower harbor/bay were detected in excess of its criterion.

AWQC

TABLE 4-5
PUBLIC HEALTH TARGET CLEAN-UP LEVELS FOR BIOTA
(LOWER HARBOR/BAY)

ESTUARY AND LOWER HARBOR/BAY
FEASIBILITY STUDY

	Hazard Index	Hazard Index	Incremental Cancer Risk
	0.2[a]	1.0[b]	10^{-5}[c]
PCBs	0.2 mg/kg[d]	1 mg/kg[d]	0.02 mg/kg
Lead	0.26 mg/kg[e]	1.3 mg/kg[e]	--

NOTES:

[a]MADEP criteria for total site noncarcinogenic risk

[b]EPA criteria for noncarcinogenic risk

[c]MADEP criteria for total site carcinogenic risk; midpoint of EPA target range of 10^{-6} to 10^{-4}

[d]The modified long-term Health Advisory for PCBs (0.0035 mg/L) was used to establish TCLs

[e]The modified MCL(p) for lead (0.005 mg/L) was used to establish TCLs

NA = Not Applicable

mg/kg = milligrams per kilogram

MADEP = Massachusetts Department of Environmental Protection

EPA = U.S. Environmental Protection Agency

PCB = polychlorinated biphenyls

TCL = Target Clean-up Level

4.3.2.2 Ecological Target Clean-up Levels for Sediment

Because there are no sediment-specific ARARs or established guidelines to use in developing clean-up levels, site-specific TCLs were developed based on the protection of aquatic biota. As discussed in Section 3.0, various methodologies exist to evaluate the effects of contaminant exposure on ecological systems. These include the EP, AET, SLC, and SQT approaches, which indicate that a sediment target level for PCBs between 0.1 and 1.0 ppm would likely be protective for most marine organisms. Further arguments for establishing a TCL within this range for the protection of ecological receptors are discussed in the following paragraphs.

As developed in the New Bedford Harbor Ecological Risk Assessment, the joint probability analysis methodology can be used to determine TCLs protective of the harbor ecosystem (E.C. Jordan Co./Ebasco, 1990a). The probabilities that particular taxa (e.g., marine fish, crustaceans, and mollusks) will experience chronic-level impacts can be evaluated by comparing the taxon-specific Maximum Acceptable Toxicant Concentration (MATC) distributions developed in the risk assessment with various sediment TCLs. Using this approach, approximately 5 and 25 percent of marine fish species are predicted to experience chronic-level impacts due to exposure to sediment pore water at PCB sediment TCLs of 0.1 and 1 ppm, respectively. The marine fish are considered the most sensitive taxa; therefore, other ecological receptors have lower probabilities of developing adverse chronic-level impacts at these TCLs.

The selection of a TCL between 0.1 and 1 ppm is also supported by results of the food-chain modeling performed by HydroQual. Predicted tissue levels in the modeled organisms inhabiting the upper estuary, estimated at 10 years after remediation of the upper estuary to 1 ppm, varied between 0.05 to 0.9 ppm (wet weight). For the winter flounder, Pleuronectes americanus, predicted levels varied between 0.2 and 0.5 ppm (wet weight). PCB concentrations as low as 0.2 ppm in the ovaries of the starry flounder was shown to be associated with effects on reproductive success (Spies et al., 1985). To allow comparisons between the HydroQual estimated whole-body concentrations and organ-specific toxicity data, it is necessary to adjust the estimated concentrations to account for differential accumulation in various fish tissues. BOS derived an edible whole-body ratio of 0.13 for winter flounder, and Ray found that the striped bass tend to accumulate PCBs in the gonadal tissue, with a ratio of muscle (edible) to gonad PCB concentrations ranging from 1:1 to 10:1 (Ray et al., 1984). Assuming the winter flounder whole-body tissue levels declined to 0.5 ppm after remediation, calculated gonadal tissue concentrations would fall between 0.065 and 0.65 ppm, using these values. Actual tissue PCB concentrations would likely be considerably lower than these estimates due to the fact that mature winter flounder migrate offshore, and only return to the estuary to spawn (Clayton, 1976).

4.4 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

Remedial action objectives are established to minimize the public health and/or ecological risks associated with contamination in the sediment, surface water, and biota from the estuary and the lower harbor/bay. TCLs were developed to assist in determining appropriate remedial action objectives and clean-up goals. Because the sediments in New Bedford Harbor are the major source of PCB and metals contamination in all media, the remedial objectives for this site were focused on reducing contamination in this medium. Although PCB concentrations in surface water and biota were detected in excess of ARARs and/or health-based criteria, reducing PCB contaminant concentrations in sediments will result in concurrent reduction of contamination in surface water and biota. Therefore, specific remedial action objectives for surface water and biota were not developed.

In addition, while direct contact exposure to lead is associated with elevated public health risks, remedial action objectives were not developed specifically for reducing metals contamination in sediments. Concentrations of cadmium or copper in shoreline sediments from the estuary and the lower harbor/bay were below their respective public health TCLs (see Table 4-4). However, most of the reported lead concentrations exceed the public health TCL of 16 ppm.

Achieving a TCL for lead of 16 ppm may not be feasible at this site because of the location in an urban and industrialized area. Lead contamination in urban soil has been well documented. It has been estimated that soils adjacent to roadways have been enriched in lead by as much as 10,000 mg/kg soil; while in urban areas and in sites adjacent to smelters, as much as 130,000 mg/kg has been measured in the upper 2 to 5 cm of soil. The range of lead concentrations in shoreline sediments from the estuary and the lower harbor/bay is consistent with the levels of lead detected in urban and industrialized areas.

Because of potential general health hazards associated with exposure to lead, the Centers for Disease Control (CDC), EPA, and the Massachusetts Department of Public Health (MDPH) have established clean-up guidelines for lead-contaminated soils. The CDC cautions that concentrations of lead in soils and dust greater than 500 to 1,000 ppm could result in elevated blood levels in children inhaling or ingesting soils. EPA has established an interim soil clean-up level for lead in soils at

500 to 1,000 ppm, which the Office of Emergency and Remedial Response and the Office of Waste Program Enforcement consider protective for direct contact exposure in residential areas (EPA, 1989). In addition, MDPH, as part of its Lead Poisoning Prevention and Control Regulations, defines "dangerous levels of lead in soil" to be 1,000 ppm or greater of lead "in soils that pose a danger to a child under six years of age" (100 CMR460.000). Both the elevated concentrations of lead and likely exposure to young children are required under this definition.

Adopting the EPA interim soil clean-up level of 500 ppm as the TCL for lead in the estuary and the lower harbor/bay will provide an adequate level of protection to public health. This criterion is based on exposure to soils in residential areas, which are considered to occur more frequently than the potential exposures to sediments at New Bedford Harbor. The average lead concentration in shoreline sediments is approximately 110 ppm, which is below the interim clean-up level of 500 ppm lead proposed by EPA. Using the EPA target level, which is the same as the CDC and MDPH criteria, will provide consistency with other remediation efforts within Massachusetts and regions of the U.S.; however, it will not achieve an HI of 0.2 as required by the MCP, or an HI of 1.0 as suggested by EPA.

In summary, a sediment TCL for PCBs of 10 ppm is recommended based on public health considerations and a sediment TCL for lead of 500 ppm is recommended based on the interim soil clean-up levels proposed by EPA, CDC, and MDPH.

However, sediment TCLs for PCBs in the lower harbor/bay must also be set at a level considered protective of the environment. Results of the baseline ecological risk assessment identify PCBs as the contaminant of concern. Sediment TCLs developed for PCBs using the various methodologies discussed in Section 3.0 and Subsection 4.3.2.2 ranged from 0.1 to 1 ppm.

Achieving a residual sediment PCB concentration of 1 ppm may not be feasible at this site given the widespread distribution of PCBs in this area. The approximate area within the estuary, lower harbor/bay of sediments containing greater than 1 ppm PCB is 960 acres (see Table 2-1). Extensive sediment sampling in the upper estuary shows that PCB concentrations between 1 and 10 ppm extend to a depth of 24 to 36 inches in this area (see Figure 2-3). It may not be feasible to remove and/or cap such a large volume/area of contaminated sediment.

Achieving a 1-ppm clean-up level through removal actions would require additional dredging and produce twice the amount of contaminated material that would be generated for a 10-ppm TCL. In addition, defining the 1-ppm PCB extent of contamination and accurately dredging to and maintaining a residual PCB concentration of 1 ppm is not known. Capping contaminated sediments to 1 ppm would involve a total area of approximately 960 acres. The feasibility of installing and maintaining an adequate cover material is also not known.

Achieving a TCL of 1 ppm PCB through either removal (e.g., dredging) or containment (e.g., capping) remedial actions will result in adverse environmental impacts. Of particular concern are the wetland areas located primarily along the eastern shoreline of the study area. Remediation of these sensitive habits would likely cause profound effects on the whole harbor ecosystem. Among the numerous functional services provided by wetland areas, the tremendous productivity is perhaps the most important; destruction of these areas would eliminate a significant contributor to the primary productivity that supports the harbor ecosystem. In addition, these areas play an essential role as refuge areas for juvenile fish, which spend many of the daylight hours hidden in the submergent vegetation, and then migrate into the open water at night to feed. (Juvenile fish suffer much greater predation risks when forced to remain in the open water during the day.) Many of these same submergent plants also serve as substrate for egg deposition by ovipositing females of many species. Finally, the vegetation in estuarine wetlands (particularly <u>Spartin</u> spp.) acts to trap sediments and to buffer the harbor from storm-related effects.

The mandated restoration of these wetlands would not result in the reestablishment of a similar community for many years; until then, the ecosystem would most likely be dramatically impaired. The large acreage involved indicates that any benefits accrued from dredging of these areas would be outweighed by the damage incurred.

Because a sediment TCL of 1 ppm is not considered technically feasible, a TCL of 10 ppm PCB is recommended as the remedial action objective for the estuary and the lower harbor/bay. This residual PCB sediment concentration provides an adequate level of protection to public health against direct contact and incidental ingestion exposure to PCBs. The potential adverse ecological impacts associated with this TCL cannot be determined at this time. However, the potential benefits obtained by remediation to 1 ppm are outweighed by the adverse ecological impacts associated with the extremely disruptive removal or containment actions necessary to achieve this TCL.

Figures 4-2 and 4-3 show the areas requiring remediation in the estuary and lower harbor/bay in order to achieve a TCL of 10 ppm.

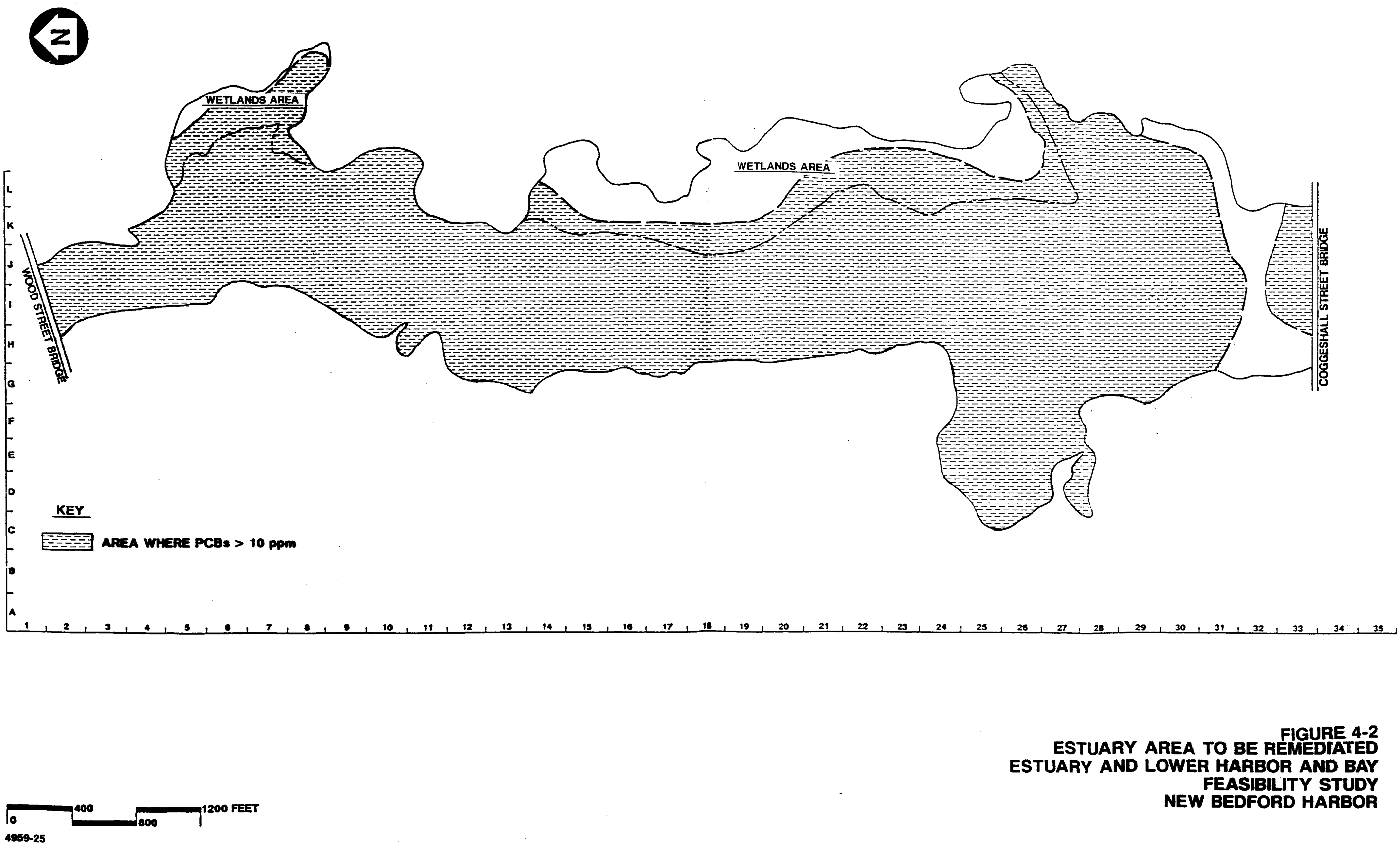


FIGURE 4-2
ESTUARY AREA TO BE REMEDIATED
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

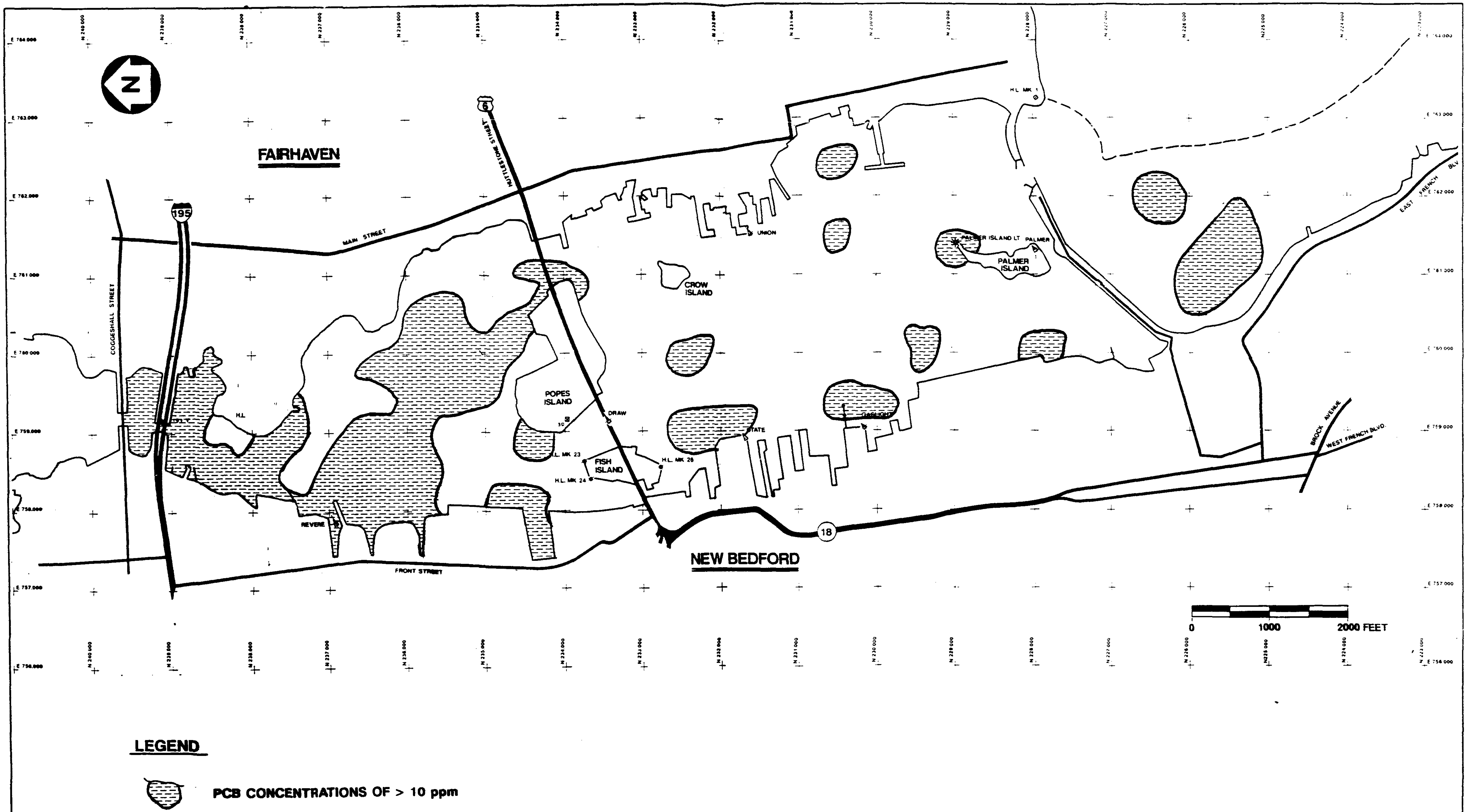


FIGURE 4-3
AREAS TO BE REMEDIATED
ESTUARY AND LOWER HARBOR AND BAY
FEASIBILITY STUDY
NEW BEDFORD HARBOR

4959-25

4.5 REMEDIAL ACTION OBJECTIVES

The remedial action objectives for the Acushnet River Estuary, New Bedford Harbor, and Lower Harbor/Bay focus on the PCB-contaminated sediment remaining after remediation and/or containment of Hot Spot Area sediment. These objectives address an overall remedy for the entire New Bedford Harbor Superfund site.

Based on the TCLs discussed in Subsection 4.3, objectives were developed to serve as guidelines in choosing a remedial alternative that will reduce the public health and ecological risks posed by contamination in the study area. The response objectives are as follows:

- Prevent human exposure to contaminated sediment in excess of 10 ppm PCB and 500 ppm lead.
- Decrease exposure by ecological receptors to PCB-contaminated sediment in excess of 10 ppm.
- Reduce PCB-water column concentrations to AWQC (0.003 ug/L) by reducing PCB sediment concentrations to 10 ppm. ppb
- Reduce PCB concentrations in biota to the FDA tolerance level (2 ppm) by reducing PCB sediment concentrations to 10 ppm.

In selecting alternatives to achieve these remedial objectives, SARA requires that alternatives use permanent solutions and innovative treatment technologies to the maximum extent practicable. In addition, preference should be given to alternatives that reduce the mobility, toxicity, or volume of the estuary and lower harbor/bay PCB-contaminated sediment.

4.6 GENERAL RESPONSE ACTIONS

General response actions describe remedial actions that will satisfy the remedial action objectives. General response actions conceptualize potential remedial measures that may be used to address remedial action objectives, including containment, sediment removal, treatment, and institutional controls, or a combination of these options. General response actions lay the groundwork for identifying specific technologies, which are discussed in Section 5.0.